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DORA M. AND ALBERT H. BANNER

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ERRATUM. *Records of The Australian Museum* Volume 33 Number 10.

On the front cover of *Rec.Aust.Mus.* Vol.33 No.10 the name of R. S. Frankenberg, one of the authors, was misspelt as 'R. S. Frankenburg'. The editor apologizes for this error.

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ERRATA. *Records of the Australian Museum* Volume 34 Number 3.

p. 364, line 19: for **Chilomyterus** read **Chilomycterus.**
The correct date of publication is not January, 1982, as on the front cover, but 15 March, 1982.

The editor apologizes for these errors.

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THE ALPHEID SHRIMP OF AUSTRALIA

Part III: The remaining alpheids, principally the genus *Alpheus*, and the family Ogyrididae

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SUMMARY

This third part of the study, based on almost 4,600 specimens, deals principally with the genus *Alpheus* Fabricius, but also included are the species of the genera *Athanopsis*, *Prionalpheus*, *Batella*, and *Metalpheus* found in Australia. We have also included the Australian species of the closely related family Ogyrididae. Since the publication of Parts I and II, we have received on loan additional collections which have contained two species of the genus *Synalpheus* which we are describing as new, one species of the genus *Athanas* and one species of the genus *Salmoneus* which are new records for Australia; these and other additional records for the species previously reported are contained in Appendix I. Another appendix gives the tabulation of the known distribution of all species known from Australian waters and a zoogeographic summary. This publication also includes the full bibliography for the three parts and a species index.

The species discussed in this paper are listed below; those that are new species or subspecies and those that are new records to Australian waters are marked by an asterisk.

Species of the genus *Alpheus*
**Alpheus acutocarinatus* De Man
**Alpheus acutofemoratus* De Man
**Alpheus alcyone* De Man
**Alpheus amirantei sizou* Banner and Banner
**Alpheus architectus* De Man
**Alpheus arethusa* De Man
**Alpheus astrinx* sp. nov.
**Alpheus australosulcatus* sp. nov.
**Alpheus balaenodigitus* sp. nov.
**Alpheus barbatus* Coutière
**Alpheus bicostatus* De Man
Alpheus bidens (Olivier)
**Alpheus bisincisus* De Haan
Alpheus brevirostris (Olivier)
Alpheus bucephalus Coutière
**Alpheus bunburius* sp. nov.
**Alpheus chiragricus* Milne-Edwards
Alpheus collumianus Stimpson
**Alpheus cristatus* Coutière
Alpheus deuteropus Hilgendorf
**Alpheus diadema* Dana
Alpheus distinguendus De Man
**Alpheus djiboutensis* De Man
**Alpheus dolerus* Banner
**Alpheus edamensis* De Man

Records of The Australian Museum, 1981, **Vol. 34 No. 1,** 1-357, Figures 1-95.

Alpheus edwardsii (Audouin)
**Alpheus ehlersii* De Man
**Alpheus euphrosyne euphrosyne* De Man
**Alpheus euphrosyne richardsoni* Yaldwyn
**Alpheus eulimene* De Man
**Alpheus facetus* De Man
Alpheus frontalis Milne-Edwards
**Alpheus georgei* sp. nov.
**Alpheus gracilis* Heller
Alpheus gracilipes Stimpson
**Alpheus hailstonei* Coutière
**Alpheus heronicus* sp. nov.
**Alpheus hippothoe* De Man
**Alpheus hutchingsae* sp. nov.
**Alpheus inopinatus* Holthuis and Gottlieb
**Alpheus labis* sp. nov.
**Alpheus leviusculus leviusculus* Dana
**Alpheus australiensis* sp. nov.
**Alpheus lobidens lobidens* De Haan
Alpheus lottini Guérin
Alpheus macrodactylus Ortmann
**Alpheus maindroni* Coutière
**Alpheus malabaricus trefzae* subspec. nov.
Alpheus malleodigitus (Bate)
Alpheus microstylus (Bate)
Alpheus miersi Coutière
**Alpheus mitis* Dana
**Alpheus moretensis* sp. nov.
Alpheus novaezealandiae Miers
Alpheus obesomanus Dana
**Alpheus ovaliceps* Coutière
Alpheus pachychirus Stimpson
Alpheus pacificus Dana
**Alpheus papillosus* sp. nov.
Alpheus paracrinitus Miers
**Alpheus paralcyone* Coutière
**Alpheus parasocialis* sp. nov.
**Alpheus pareuchirus imitatrix* De Man
**Alpheus pareuchirus pareuchirus* Coutière
Alpheus parvirostris Dana
**Alpheus polyxo* De Man
**Alpheus pubescens* De Man
**Alpheus rapacida* De Man
Alpheus rapax Fabricius
**Alpheus serenei* Tiwari
Alpheus socialis Heller
**Alpheus splendidus* Coutière
Alpheus spongiarum Coutière
**Alpheus staphylinus* Coutière
Alpheus stephensoni Banner and Smalley
**Alpheus strenuus cremnus* subspec. nov.
Alpheus strenuus strenuus Dana
**Alpheus sudara* Banner and Banner
**Alpheus sulcatus* Kingsley
**Alpheus tasmanicus* sp. nov.

Alpheus villosus (Olivier)
**Alpheus* sp.

Genera other than *Alpheus*
Athanas polynesia Banner and Banner
**Athanopsis australis* sp. nov.
Batella parvimanus (Bate)
**Metalpheus paragracilis* Coutière
Metalpheus rostratipes (Pocock)
**Ogyrides delli* Yaldwyn
Ogyrides mjobergi (Balss)
**Prionalpheus triarticulatus* Banner and Banner
**Salmoneus sibogae* (De Man)
**Synalpheus paralaticeps* sp. nov.
**Synalpheus tijou* sp. nov.

We have placed the following species and subspecies of *Alpheus* in synonymy:
A. bisincisus malensis Coutière 1905 (=*A. bisincisus* De Haan 1850)
A. bisincisus stylirostris Coutière 1905 (=*A. bisincisus* De Haan 1850)
A. bisincisus variabilis De Man 1909 (=*A. bisincisus* De Haan 1850)
A. braschi Boone 1931 (=*A. parvirostris* Dana 1852)
A. bullatus Barnard 1955 (=*A. architectus* De Man 1897)
A. collumianus inermis Banner 1956 (=*A. collumianus* Stimpson 1861)
A. collumianus medius Banner 1956 (=*A. collumianus* Stimpson 1861)
A. collumianus probabalis Banner 1956 (=*A. collumianus* Stimpson 1861)
A. dissodontonotus Stebbing 1915 (=*A. bidens* (Olivier) 1811)
A. eurydactylus De Man 1920 (=*A. euphrosyne euphrosyne* De Man 1897)
A. gracilis alluaudi Coutière 1905 (=*A. gracilis* Heller 1861)
A. gracilis luciparensis De Man 1911 (=*A. gracilis* Heller 1861)
A. gracilis simplex Banner 1953 (=*A. gracilis* Heller 1861)
A. hailstonei assimulans De Man 1908 (=*A. hailstonei* Coutière 1905a)
A hailstonei laetabilis De Man, 1908 (=*A. hailstonei* Coutière 1905a)
A. hailstonei paucispinata Banner 1953 (=*A. hailstonei* Coutière 1905a)
A. luciae Barnard 1946 (=*A. sulcatus* Kingsley 1878)
A. macrochirus Richters 1880 (=*A. sulcatus* Kingsley 1878)
A. malhaensis Coutière 1908 (=*A. collumianus* Stimpson 1861)
A. pareuchirus leucothea De Man 1909 (=*A. pareuchirus pareuchirus* Coutière 1905)
A. pomatoceros Banner and Banner 1966b (=*A. splendidus* Coutière 1897a)
A. praedator De Man 1908 (=*A. bidens* (Olivier) 1811)
A. sp. Forest and Guinot 1958 (=*A. inopinatus* Holthuis and Gottlieb 1958)
Crangon bucephalus var. Rathbun 1914 (=*A. bucephalus* Coutière 1905a)

We have reduced *Alpheus richardsoni* Yaldwyn 1971 and *A. langi* (Schmitt) 1926 to subspecific rank, creating new combinations *A. euphrosyne richardsoni* and *A. euphrosyne langi*. We have also reduced *A. bouvieri* Milne-Edwards 1880 to *A. leviusculus bouvieri*, and have raised *A. bouvieri hululensis* Coutière 1905a to specific rank as *A. hululensis*.

CONTENTS

INTRODUCTION

This, the third portion of our tripartite work on the family Alpheidae in Australian waters, was originally planned to contain only the genus *Alpheus*, but new specimens have required us to include the genera *Athanopsis*, *Prionalpheus* and *Metalpheus;* we also discovered that we forgot to include *Batella* in Part I, and have chosen to include records of two species of the related family, *Ogyrididae*. In the years since Parts I and II were written (dates of submission 1971 and 1974) new species and new records which extend the ranges of previously reported genera have been sent to us; these will be placed in Appendix I. The new collection records, recorded by our alphameric system and listed up to 1971 in the Appendix of Part I, are given in Appendix II. In Appendix III we have given the current names for those species previously reported from Australia in the literature under other generic or specific names. In Appendix IV we have given a zoogeographic summary for all Australian species. Finally in Appendix V we list the *errata* we have been able to detect in the first two parts. This final part also carries the bibliography and an index for all three parts of the study. As in Part II (p. 271) we have continued to mark unpublished distributional records with an asterisk — however, some of these will have been published by the time this paper appears.

Inasmuch as this part contains the bibliography, we have shortened our references form under synonymy to the author, date, page and relevant figures; the full reference may be found in the bibliography. Also in an effort to save printing space, we have abbreviated references except under synonymy to our own works to *B* and *B&B;* for this we ask the reader's indulgence.

In this paper, as in the parts previously published, the lengths given are total body lengths from the tip of the rostrum to the tip of the telson with the specimen laid as

straight as possible, unless "carapace length" is specified. On appendages, the lengths are from articular surfaces to articular surfaces (where the articulation is diagonal, as on the merus of the chelipeds, the maximum length at the articulation is used); the widths are measured at the maximum width, but excluding the width with any teeth or other projections. Further, in our usage spines and setae (or, at times, hairs) are articulated at their bases, while teeth, knobs and bosses are inarticulated projections of the exoskeleton.

SUPPORT AND ACKNOWLEDGEMENTS

Since the publication of Part I, wherein we acknowledged the aid to the studies of institutions and individuals, most of whom have continued to help us, we have received further aid and assistance that we here wish to gratefully acknowledge: continued support by the U.S. National Science Foundation through Grant BMS 74-11844 (formerly GB-42498); the loan of specimens from Muséum d'Histoire Naturelle Ville de Genéve, Geneva, Switzerland, and the South African Museum, Capetown, South Africa; collections made by the Fisheries and Wildlife Department, Melbourne, Victoria; personal collections made by R. A. Birtles and L. P. Zaan of James Cook University of North Queensland, Townsville, Qld; J. R. Randall of the Bishop Museum, Honolulu, Hawaii; Shirley Trefz of the Leeward Community College, Honolulu, Hawaii and John Garth of the Allan Hancock Foundation, Los Angeles, California. We specially wish to thank Dr F. A. Chace Jr of the Smithsonian Institution and Dr John C. Yaldwyn of the National Museum of New Zealand for the many patient hours they have spent in reading the manuscript of this portion, and for their many helpful suggestions, ranging from spelling to scientific approach and content.

During 1975 the following museums graciously allowed us space in their institutions and aided us in the examination of their collections for this and related studies: the British Museum (Natural History), London, England; the Indian Museum, Calcutta, India; the Invertebrate Reference Museum, Karachi, Pakistan; the Muséum National d'Histoire Naturelle, Paris, France; the National Museum of Kenya, Nairobi, Kenya; the Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands; the University Museum of Zoology, Cambridge, England; the Universitetets Zoologiske Museum, Copenhagen, Denmark; the Zoologisch Museum, Amsterdam, The Netherlands.

As we have added five genera listed above to the nine genera given in our 1973 key (p.298), we believe it will be helpful to provide a new key to all genera of the two families this work embraces. For the previously published sections, the references are to the part number and page.

KEY TO GENERA OF ALPHEIDAE AND OGYRIDIDAE FOUND IN AUSTRALIAN WATERS

1. Eyestalks with long slender and exposed peduncles reaching to near end of antennular peduncles. ....Family *Ogyrididae* (p.287).
   — Corneas of eyes exposed or covered by carapace, but if peduncle exposed, never with corneas reaching to end of first antennular article. Family *Alpheidae* 2
2. (1) Corneas of eyes fully exposed in dorsal and lateral view except for partial concealment by anterior teeth of carapace 3
   — Corneas of eyes concealed in dorsal view and partially to completely concealed in lateral view by anterior extension of carapace 5
3. (2) Corneas and peduncles exposed in dorsal view, corneas somewhat

degenerate; rostrum vestigial. .... *Automate* (I:299)
— Corneas alone exposed, normally developed; rostrum well-developed, reaching beyond eyes 4

4. (3) Dactylus of large chela usually carried in lateral position; rostrum long and, in lateral view, acute. .... *Athanas* (I:303)
— Dactylus of large chela always carried in inferior position; rostrum short and, in lateral view, rounded. .... *Aretopsis* (I:330)

5. (2) Large chela carried flexed with merus expanded and excavated to accommodate it 6
— Large chela carried extended, not folding back into an excavated merus. 7

6. (5) Rostrum with a ventral vertical keel; tip of telson rounded. *Athanopsis* (p. 9)
— Rostrum may carry dorsal carina but never a ventral keel; tip of telson notched .... *Salmoneus* (I:334)

7. (5) Fingers of large chela with serrations or teeth, never with a plunger and socket 8
— Fingers of large chela without serrations or teeth, with a strong plunger on dactylus that fits into socket on base of propodal finger (in a few species the device is reduced to a heavy crest and a propodal groove, or absent) 11

8. (7) Rostrum completely lacking and extended front of carapace rounded in dorsal view; dactylus of large chela carried in inferior position. .... *Betaeus* (I:347)
— Rostrum present, of various development; dactylus of large chela carried in superior or lateral position 9

9. (8) Fingers of chelae of second legs about one-tenth length of palm and bearing dense tuft of scaley or setiferous bristles; sixth abdominal segment
lacking articulated pleura .... *Batella* (p. 15)
— Fingers of chelae of second legs approximately equal to length of palm, without dense setae; sixth abdominal segment with articulated pleura.. 10

10. (9) Mouthparts as normal for family, mandible with molar process and palp .... *Alpheopsis* (I:336)
— Mandible without molar process and palp, incisor process greatly expanded and bearing few, but strong, teeth; other mouthparts except third maxilliped modified .... *Prionalpheus* (p. 12)

11. (7) Body highly compressed; carapace with knife-like mid-dorsal keel for its entire length .... *Racilius* (I:350)
— Body not markedly compressed; if carapace bearing keel, keel not knife-like posteriorly 12

12. (11) With pterygostomial margin usually produced; without anal tubercles; without mastigobranchs and setobranchs .... *Synalpheus* (II:271)
— With pterygostomial margin rounded, never angular; usually with anal tubercles; bearing mastigobranchs and setobranchs at least on anterior thoracic legs 13

13. (12) With normal, not protuding mouthparts; third maxilliped with trigonal, not flattened, basal article; *appendix masculina* of second pleopods of male not reaching beyond end of endopod. .... *Alpheus* (p. 18)

— With mouthparts enlarged, with labrum protruding and enclosed by incisor process of mandible; third maxilliped with basal article expanded and flattened; *appendix masculina* of second pleopod of male reaching beyond end of endopod. ....*Metalpheus* (p. 280)

Genus **Athanopsis** Coutière

Athanopsis Coutière, 1897b:301; 1899:324.
Type species: *Athanopsis platyrhynchus* Coutière

DIAGNOSIS: "Rostrum very peculiar, in the form of a vertical lamella, rounded and smooth, placed edgewise ("*de champ*" — quotation Coutière's). Without supra-ocular teeth. Orbital margin with extra-corneal tooth only distinct, located superiorly and not laterally.

"Eyes nearly invisible from above, placed as in the genus *Athanas*. Stylocerite as in *Athanas*, but wide and obtuse at its tip. Scaphocerite broad, lateral spine small carpocerite large, longer than the antennal scale, distal flagella robust.

"Chelipeds very asymmetrical (at least in the male, the female being unknown) palm of the large chela inflated, carpus very short, both of these articles folding into an excavation of the merus like that of the female of *Athanas djiboutensis*.

"All the other characters are like *Athanas* and of similar size." (Coutière, 1899:324). (Translated from the French by the authors.)

DISCUSSION: In his original description of the genus, Coutière also pointed out that the carpus of the second legs was of 5 articles, the sixth abdominal pleura were articulated, that the telson was lacking anal tubercles and that the branchial formula did not include an arthrobranch on the third maxillipeds, but did include 5 pleurobranchs.

An outstanding characteristic of this genus is the development of the distal portions of the rostrum in the flat vertical, or laterally compressed, plate that hangs below the level of the carapace anterior to the eyes; the anterior margin, when seen in lateral view, is rounded. A somewhat similar condition is found in the genus *Aretopsis* De Man (I:330); the two genera can easily be distinguished by the large chelae of the males (no females with intact chelae have ever been reported for *Athanopsis*) which are carried folded against an expanded merus in this genus but carried extended, with the dactylus in an inverted position, in *Aretopsis*.

The genus was previously known only by the type species, *A. platyrhynchus*, that Coutière described on the basis of two males from Djibouti located at the head of the Gulf of Aden. These specimens were collected under a rock partially buried in sand ("*le sable*") at the low tide level. They are the only specimens ever reported.

Athanopsis australis sp. nov.

Fig. 1

HOLOTYPE: 16 mm female from sandy sediment. 8 m. Beaumaris, Port Phillip Bay, Victoria, 23/8/71. (VM 918, see Appendix II). AM P:30808.

DIAGNOSIS: Rostrum characterized by having tip developed as a compressed dorsoventral lamella, a continuation of a dorsal carina arising between eyes and of a ventral ridge that hangs below base of rostrum. Tip acute in dorsal view, rounded in profile, and reaching beyond end of first antennular article. In dorsal view rostral triangle

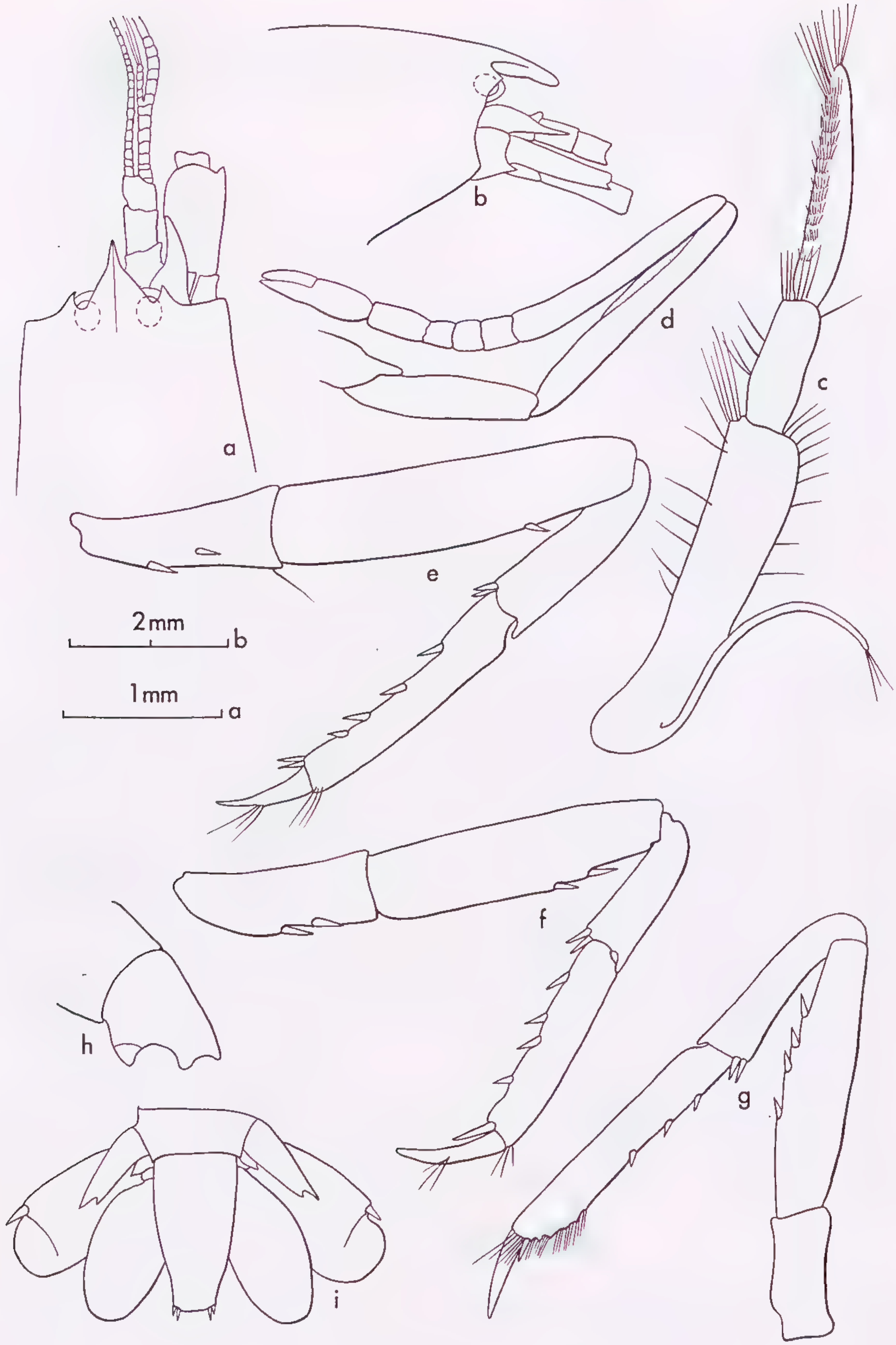

Fig. 1 *Athanopsis australis* sp. nov.
Holotype (female), **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped, medial face; **d.** second leg; **e.** third leg; **f.** fourth leg; **g.** fifth leg; **h.** sixth abdominal segment; **i.** telson and uropods. a, b, h, i scale a; c, d, e, f, g. scale b.

almost equilateral, laterally arising from midline of eyes, but with compressed portion of rostral ridge extending beyond triangular portion; in lateral view triangular portion of rostrum is much thinner than the dorsoventral depth of lamella and joins lamella near dorsal surface. Orbital teeth small, acute, with margins more abrupt medially than laterally. Eyes with transparent portion of cornea and some of pigmented portion extending beyond anterior margin of carapace in both dorsal and lateral views.

Antennular articles short and broad, second article only slightly longer than broad and slightly longer than visible part of first; first and third article subequal. Stylocerite relatively narrow in distal portion with obtuse tip (in dorsal view), nearly reaching to end of second antennular article. Broad squame of scaphocerite reaching well beyond antennular peduncle, lateral tooth small. Carpocerite longer than scaphocerite and reaching beyond antennular peduncle by length of its third article. Basicerite bearing short subacute tooth distally.

Ratio of length of articles of third maxilliped, starting at basal article: 10:3:6. Ultimate article bearing the usual rows of setae on inner face; tip bearing a tuft of moderately long setae.

Both chelipeds are missing but bases show symmetrical development.

Ratio of carpal articles of second legs: 10:1:1:1:2; first article markedly longer than sum of four following.

Ischium of third leg 0.5 as long as merus and bearing two spines. Merus 4.2 times as long as broad, unarmed distally, but bearing at two-thirds of length an acute spine. Carpus 0.5 as long as merus, superodistal margin terminating as a subacute tooth, inferodistal margin not projected but bearing 2 short spines. Propodus 0.7 as long as merus and bearing on inferior margin 4 spines and 2 distally. Dactylus simple, 0.35 as long as propodus and bearing patch of setae on superior margin slightly distal to middle. Fourth leg similar to third but bearing 2 spines on inferior margin of merus. Ischium of fifth leg unarmed; merus with 4 spines; superodistal tooth of carpus less developed than that of third leg; propodus bearing 3 spines in proximal half and well-developed tuft of setae on distal third with tip also bearing strong spine.

Pleura of sixth abdominal segment articulated. Telson 3 times as long as broad with posterior margin broad and somewhat arcuate; dorsal surface without the usual 2 pairs of spines. Outer tooth of sympodite of uropods long, reaching almost to middle of outer branch of uropod and terminating as strong acute tooth laterally and a lesser acute tooth medially; outer branch of uropod with usual distal articulation and tooth.

DISCUSSION: While our specimen lacks the chelae, we assign it with little doubt to the genus *Athanopsis* because of the unique development of the tip of the rostrum as a distinct keel (illustrated in Coutière, 1899: figs. 17, 18). Coutière described the development of the chelae of his two males as like the development in *Athanas djiboutensis* Coutière (*op. cit:* figs. 210, 211). We have pointed out (1960:140) that the development of the chelae in so many species of *Athanas* is correlated with both sex and maturity. Perhaps similar conditions will be found in this genus. In any case, the large chela was shown by Coutière to be heavy and carried flexed against an excavate merus.

The principal difference between *A. australis* and *A. platyrhynchus* is in the spines found on the meri of the third, fourth and fifth legs, all of which are unarmed in *A. platyrhynchus*. Other minor differences also exist: In *A. platyrhynchus* the rostral keel is deeper anteriorly than posteriorly (*op. cit*: fig. 18) whereas in this species the keel tapers slightly towards the tip. In Coutière's species in the antennular and antennal peduncles

(*op. cit:* fig. 135), the stylocerite is blunt and reaches only to the middle of the second antennular article and the squamous portion of the scaphocerite does not quite reach to the tip of the third antennular article, while in this species the more acute stylocerite reaches nearly to the end of the second article and the squame reaches beyond the end of the third. Coutière also described the first carpal article of the second leg as being equal to the sum of the following four, while in this species it is 1.7 times as long.

The name refers both to the existence of the species in the South Temperate Zone and to its type locality in the southernmost part of the Australian sub-continent.

The holotype will be placed in the Australian Museum.

Genus **Prionalpheus** Banner and Banner

Prionalpheus Banner and Banner, 1960b:292.

Type species: *Prionalpheus triarticulatus* Banner and Banner.

DIAGNOSIS: "General form of body, orbital hoods and appendages similar to *Alpheopsis,* but distinguished from *Alpheopsis* by the highly modified mouthparts. Mandible without palp and molar process, and with incisor process asymmetrically developed into long, sharp teeth-like processes on one side, and either somewhat similar teeth or with rounded processes on the other. First maxilla with middle lobe variously expanded, inner lobe bearing several to many strong spines, outer lobe somewhat reduced. Second maxilla reduced, with endites reduced or absent, palp present, scaphognathite reduced. First maxilliped with coxal endite probably present in all species, but joined to enlarged basal endite; endopod without articulations; exopod long and well developed, but also without articulations; epipodite reduced. Second maxilliped with endopod united with basipod, and of three or possibly four articles, with penultimate article rounded and expanded, ultimate article greatly reduced. Third maxillipeds of form normal for the family. Large chelipeds moderately heavy, symmetrical, carried extended, with simple armature on fingers, with development reminiscent of *Alpheopsis equalis* Coutière. Carpus of second leg with three to five articles. Third legs slender, with biunguiculate dactyli in all species known. Sixth abdominal segment with articulated pleura. Outer uropod with shoulder bearing a strong movable spine, and 2-5 teeth. Telson normal for the family.

"Branchial formula with 5 pleurobranchs, no arthrobranchs, and epipodites on only first and second maxilliped." (From B & B, 1971:263).

DISCUSSION: This genus, closest in most characteristics to the genus *Alpheopsis,* was separated from this genus and all others within the family by the unique development of the mouthparts. Four species have been placed in this genus to date: *P. triarticulatus* B & B, listed below and previously known only from Fiji; *P. brachytomeus* B & B known from a specimen from Fiji and one from Tahiti; *P. sulu* B & B, known from 9 specimens from the southern Philippines, and *P. fissipes* (Coutière) (previously *Alpheopsis*) known from a single specimen dredged at 50-78 fathoms in the Seychelles. The four species are separated principally on the modifications of their mouthparts and the number of articles in the carpus of the second legs; a table giving their separation is presented in our 1971 paper (B & B, 1971:263). While the first three species have been collected in shallow subtidal waters from old coral heads, nothing is known of their specific habitats nor of their living habits that would demand such strange mouthparts.

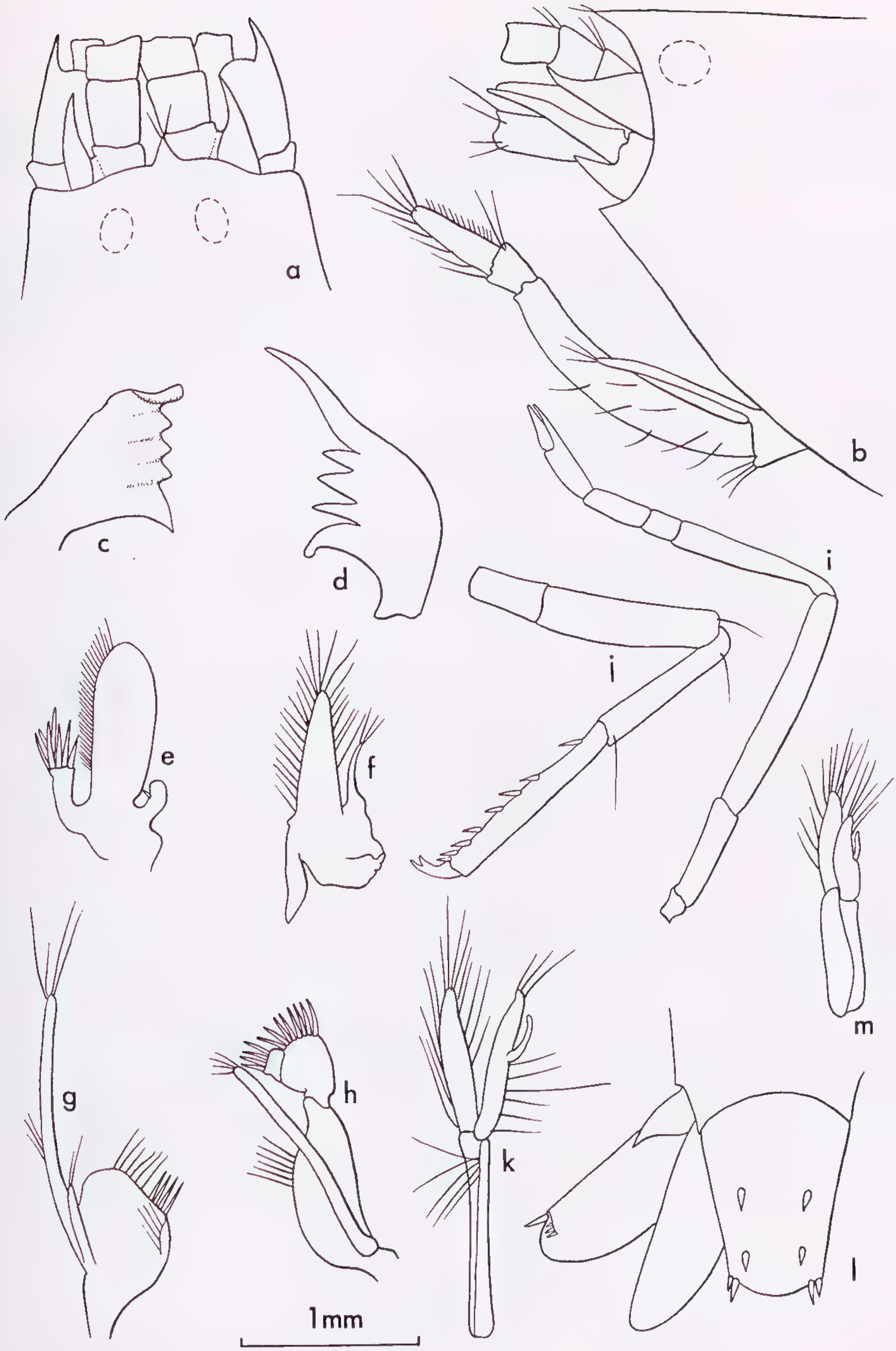

Fig. 2 *Prionalpheus triarticulatus* B&B
11 mm female from 75-LIZ 4. **a.** Anterior region, dorsal view; **b.** anterior region, lateral view with third maxilliped; **c, d.** mandibles, right and left; **e.** first maxilla; **f.** second maxilla; **g.** first maxilliped; **h.** second maxilliped; **i.** second leg; **j.** fourth leg; **k.** second pleopod of female; **l.** telson and uropods. 10 mm male from 75-LIZ 4. **m.** second pleopod of male. All figures same scale.

Prionalpheus triarticulatus Banner and Banner

Fig. 2

Prionalpheus triarticulatus Banner and Banner, 1960b:293, Fig. 1; 1971:265, Fig. 1.

SPECIMENS EXAMINED: Two specimens from 75-LIZ 4 (AM P. 28113).

DIAGNOSIS: Rostrum triangular, set off from slightly convex anterior margin of carapace, acute tip reaching to end of first antennular article, tip with two hairs usually hanging downward; without dorsal carina. Anterior carapace obscuring eyes from dorsal and lateral views and without swollen orbital hoods; without trace of ocular teeth; pterygostomial angle produced and acute.

Basal articles of antennules short and heavy, with second article broader than long; lateral tooth of stylocerite strong, with tip reaching to near end of second antennular article. Squamous portion of scaphocerite broad, reaching to end of second antennular article; lateral tooth pronounced, reaching well beyond antennular peduncles. Lateral tooth of basicerite heavy but acute, and reaching as far forward as distal end of first antennular article. Carpocerite as long as antennular peduncle. Either basal article of antennules or antenna, or sclerite at their bases on ventral side bearing a sharp acute tooth (see 1960b:Fig. 1c).

Mouthparts protrudent and conspicuous in lateral view; mandible large, expanded and flattened, curved distally. Right mandible bearing five acute teeth, posterior tooth acute, longer than middle teeth and curved (acute tip not visible in Fig. 2c; see 1960b, Fig. 1e, f); three middle teeth strong, acute and nearly equal in size. Anterior tooth of left mandible awl-shaped, almost four times length of middle teeth and fitting into almost closed groove developed by corresponding tooth of right mandible; no trace of palp or *pars molaris.* First maxilla with middle lobe greatly expanded, 2.5 times as long as broad, distally rounded and bearing a series of setae on inner margin; inner lobe short, tip truncate and bearing at its tip a circlet of heavy setae as long as lobe. Outer lobe smaller than inner and bearing a single weak spine. Second maxilla reduced in size with total length of scaphognathite equal to length of first maxilla; endites reduced to small lobes; palp without segments and bearing only a few setae. Setiferous scaphognathite narrow with posterior lobe only two times as long as broad. First maxilliped with endite rounded, bearing a number of thin setae and four heavy setae; endopod with no apparent segmentation, bearing a few setae; exopod well-developed, epipodite partially lost in dissection. Second maxilliped apparently with only three or four articles in endopod; basal article with maximum length over twice the breadth, inner margin bearing several setae; next article distally expanded, bearing strong spines on distal margin. Ultimate article much broader than long, about half as wide as penultimate article and bearing a cluster of strong spines distally. Third maxillipeds not highly modified. Ratio of articles: 10:1.4:3.2. First article flattened, last article with a few longer setae at tip, and with medial face covered with rows of strong, short, hook-like spines.

Chelipeds lacking in both specimens. In holotype: "Ischium 0.3 length of merus; merus four times as long as broad, unarmed, bearing few scattered setae; carpus somewhat cyathiform, distally expanded to accommodate base of propodus; palm slightly shorter than fingers, 0.7 as long as broad, somewhat compressed; fingers heavy, fixed finger bearing fine serrations, dactylus with straight cutting edge, free margin armed with setiferous bristles; tips of fingers crossing." (B&B, 1960b:295). (In the related *P. sulu* B&B, chelae with bilateral symmetry and no sexual differentiation).

Carpus of second leg bearing only three articles with ratio: 10:2:4.

Third leg missing but fourth similar to third of holotype. Ischium of fourth leg inermous and 0.4 length of merus. Merus four times as long as broad, inermous. Carpus almost as long as merus, superodistal margin slightly projected, inferodistal margin rounded. Propodus a little longer than merus with six spines and a pair distally on inferior margin. Dactylus biunguiculate, inferior unguis a little shorter than superior, but nearly equal in width at base.

Second pleopods of female with long, slender protopodite, 14 times as long as broad, bearing a few long setae distally; both rami long and thin with *appendix interna* arising at about 0.6 of length of endopod and about 0.3 of that branch. Second pleopod of male shorter and heavier with protopodite three times as long as broad, *appendix interna* arising near middle of endopod; *appendix masculina* lacking.

Telson 2.2 times as long as broad distally, 1.6 times as broad proximally as distally, sides with uniform taper, tip broadly arcuate, dorsal and terminal spines small. Uropods narrow, outer uropod without distal articulation, with sub-terminal spine flanked by three smaller spines.

DISCUSSION: While the 7 mm female specimen is considerably smaller than the 10.7 mm female holotype, it and the male agree well with the Fijian specimen. The general body proportions, the proportions and armature of the appendages that were left were surprisingly the same, even to the two bristles on the tip of the rostrum, the four light spines (or heavy setae) on the inner margins of the endite of the first maxilliped, the shape and armature of the 2 ultimate articles of the second maxilliped, and the three flanking spines next to the major spine of the outer uropods. The only difference between these specimens and the holotype is in the inner lobe of the first maxilla which carried only four spines in the holotype, the terminal one being conical, almost as long as the lobe and finely setiferous, while in this specimen the lobe carries a cluster of heavy spines. While the differences in the armature of the lobe may be an indication of a specific difference that might be reflected in other parts such as the missing chela, we are loath to consider it so with both the holotype and these two specimens all being fragmentary.

The sexual differentiation of the second pleopods has not been remarked upon before. However, it may be that the lack of an *appendix masculina* in this male is a mark of sexual immaturity.

BIOLOGICAL NOTES: These specimens were collected from "solid reef rock" overgrown with algae at about 60 feet deep, which was broken up after being removed. Dr Patricia Hutchings could offer no further clues as to the shrimp's specific habitat. The holotype came from dead heads of coral found in the middle section of a fringing reef.

AUSTRALIAN DISTRIBUTION: These specimens came from off Lizard Island in the northern Great Barrier Reef.

GENERAL DISTRIBUTION: Only the holotype from Fiji was known previously.

Genus **Batella** Holthuis

Cheirothrix Bate, 1838:532 (name preoccupied)

Batella Holthuis, 1955a:92.

TYPE SPECIES: *Cheirothrix parvimanus* Bate.

DIAGNOSIS: Orbital hoods concealing eyes in dorsal and lateral but not anterior

view, with acute orbital teeth.* Median line of carapace carrying or not protuberances in the gastric region. Pterygostomial angle projecting and acute.

Antennular peduncle normal; stylocerite well-developed; outer flagellum bifurcate or simple. Basicerite with tooth; carpocerite slender; scaphocerite foliaceous with short lateral spine.

Mandible reduced, deeply bifurcate and without palp; molar process cylindrical, terminating in pyramidal projection; incisor process narrow, spatulate and densely furnished with bristles at tip. First maxilla with well-developed bilobed palp. Second maxilla with thumb-like palp and well-developed scaphognathite. First maxilliped with large oval endopod fringed with plumose setae and without articulations. Second maxilliped normal, with rudimentary epipod. Third maxilliped slender, bearing rudimentary arthrobranch and no epipod.

Large cheliped of symmetrical development (see preceding footnote) carried forward, fingers compressed with serrated teeth on proximal two-thirds of cutting surfaces. Inferior face of merus keeled.

Carpus of second leg with five articles; chela slender and tapering, about as long as carpus with fingers minute, carrying tufts of setae longer than fingers.

Posterior legs of normal form, dactyli either simple or biunguiculate; propodi armed with spines.

Abdominal pleura rounded, sixth pleura not articulated. Telson and uropods normal.

Branchial formula: five pleurobranchs, one arthrobranch, two epipodites and three exopods.

(Diagnosis adapted from Miya and Miyake, 1968b:114).

DISCUSSION: Only two specimens of this genus are known: Bate's original specimen and one reported by Miya and Miyake (1968b:116) from Japan *(B. bifurcata)*; both were somewhat fragmentary but are of different species. In the examination of their specimen, Miya and Miyake discovered it lacked a palp on the mandible in addition to the unusual chelae of the second legs. Through the co-operation of Dr R. W. Ingle of the British Museum (Natural History) who re-examined the holotype, it was ascertained that the character was held in common between the two species. On the basis of their specimen and the information on Bate's, Miya and Miyake modified the generic description.

The genus is separated from all others of the family Alpheidae by the minute size of the fingers and the heavy setae on the chelae of the second legs, by a ventral keel on the merus of the chelipeds and by the lack of a mandibular palp.

Batella parvimanus (Bate)

Fig. 3a-e

Cheirothrix parvimanus Bate, 1888:533, pl.96, Fig. 2.

Batella parvimanus Holthuis, 1955a:92, Fig. 62b (after Bate).

*Dr F. A. Chace Jr of the Smithsonian Institution has kindly told us of a specimen possibly of *A. bifurcata* Miya and Miyake from the Philippines (not yet published upon). In this the orbital teeth turn somewhat upward and the eyes are fully exposed anteriorly; it also has symmetric development of the first chelipeds.

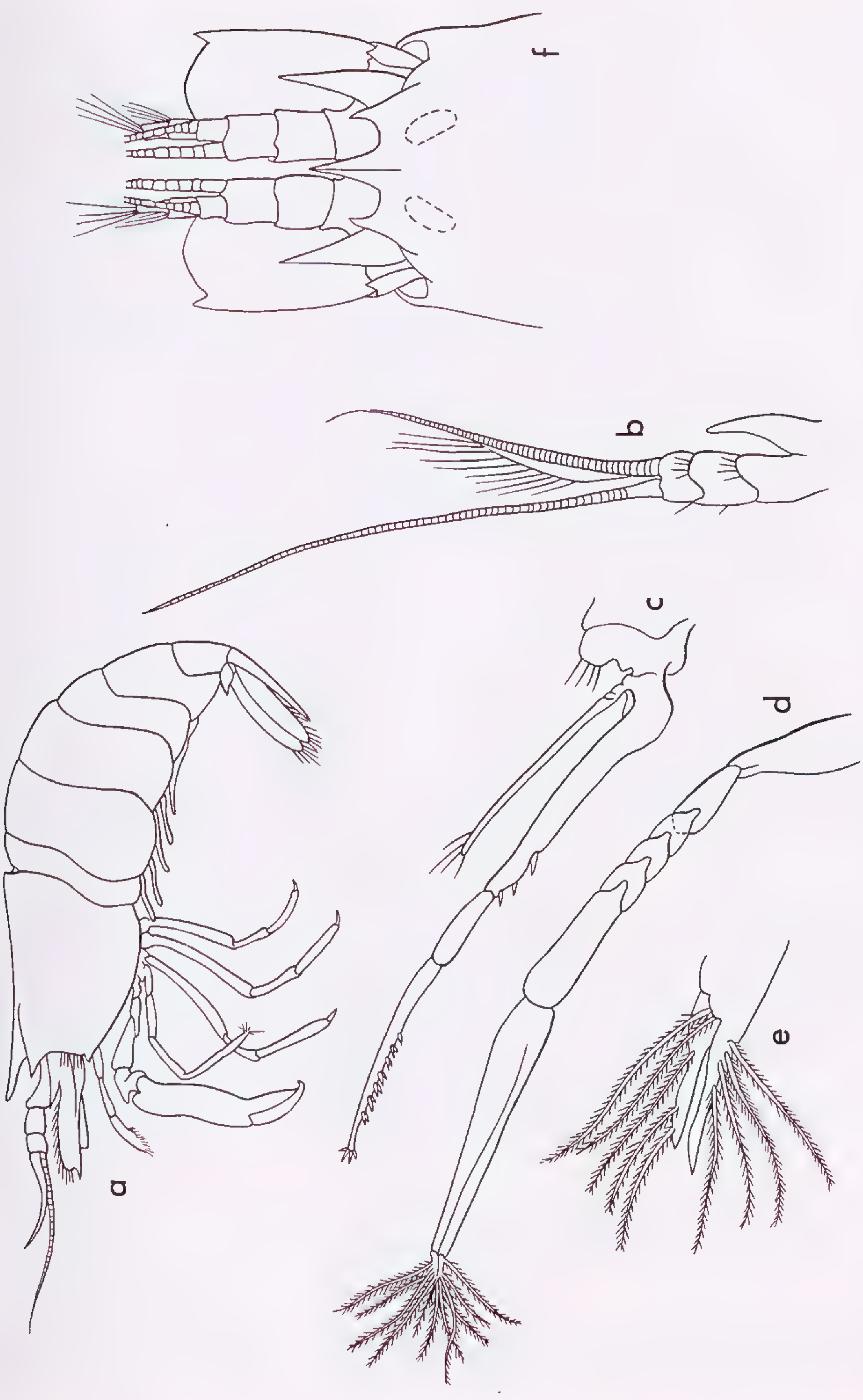

Fig. 3 *Batella parvimanus* (Bate)
a. Shrimp, lateral view; **b.** antennule; **c.** third maxilliped; **d.** second leg; **e.** distal end of second leg. (All figures after Bate) *Batella bifurcata* Miya and Miyake **f.** Anterior region, dorsal view. (After Miya and Miyake).

Confer: Miya and Miyake, 1968b:113.

DIAGNOSIS: Rostrum acute, reaching to end of first antennular article; acute orbital teeth nearly as long as rostrum. "Opthalmus . . . is visible in front when viewed anteriorly." Viewed laterally, first antennular article nearly as long as second and third combined. Stylocerite acute, reaching well beyond end of first article. Outer flagellum simple, not bifurcate. Scaphocerite reaching end of antennular peduncles; squamous portion broad, lateral tooth small but acute. Carpocerite reaching to middle of third antennular article and bearing a slender flagellum about as long as entire animal. Third maxilliped with proximal article of endopod shown with strong subterminal spine and several spinules.

Only chela known slender, sub-cylindrical, five times as long as broad with fingers occupying the distal third (from plate). Fingers turned slightly inward, dactylus markedly curved at tip, overhanging propodal finger when closed. Other chela missing.

Ischium of second leg somewhat swollen in middle and tapering distally. Carpus of five articles, a little longer than merus; articles with approximate ratio of 10:6:6:6:9 (from figure). Chela is almost as long as carpus and tapers markedly distally. Dactylus and propodal finger minute, about 0.1 length of palm (from figure) and almost obscured by a distal tuft of long hairs. Bate states: "These hairs appear to be the same diameter from base to apex, but near the base and for about half their length the surface appears to consist of scales which gradually pass into minute hairs forming a closely packed fur towards the extremity."

Third leg longer and heavier than second, with no armature described or figured, merus seven times as long as broad (from plate). Dactylus simple.

Telson long, slender and tapering, similar to that of the genus *Alpheus*. Uropods are longer than telson and outer branch with articulation. (Adapted from description and figures of Bate.)

DISCUSSION: Miya and Miyake separate their species, *B. bifurcata,* on the basis of its possession of: (1) a protuberance on the carapace in the midline of the gastric region; (2) a bifurcation of the outer antennular flagellum; (3) biunguiculate dactyli on the third to fifth legs; and (4) a relatively longer rostrum and stylocerite.

Inasmuch as we had no specimen of *B. parvimanus* we are presenting a copy of Bate's original drawings (Challenger Report pl.96, Fig. 2). With the permission of Drs Miya and Miyake we are also including a dorsal view of the carapace of *B. bifurcata*.

BIOLOGICAL NOTES: Bate's specimen was 13 mm long and it was collected at eight fathoms. *B. bifurcata* was longer, 19.6 mm, and was dredged at a depth of 156 m.

AUSTRALIAN DISTRIBUTION: Bate's specimen, caught off Cape York, Qld., is the only specimen of this genus reported from Australia.

Genus **Alpheus** Fabricius

Crangon Weber, 1795:94. (Use of name suppressed; *nec Crangon* Fabricius 1798:387, 409).

Alpheus Fabricius, 1798:380, 404.

[For other synonyms see Holthuis 1955a:89]

TYPE SPECIES: *Alpheus avarus* Fabricius, 1798 [selected by Latrielle, 1810, according to Holthuis *loc. cit.*]. (See under *A. avarus,* Appendix III.)

DIAGNOSIS: Carapace continued anteriorly to form orbital hoods which completely enclose the eyes except on ventral side. Orbital hoods frequently projecting as rounded to acute teeth or ridges and usually demarked interorbitally from rostral base by shallow or marked depressions. Rostrum usually present and continued posteriorly as carina. Pterygostomial margin of carapace rounded; with cardiac notch. Orbitorostral process almost always present.

Antennules usually short, frequently with basal peduncular article and stylocerite reduced. Squame of scaphocerite at times reduced; basicerite usually bearing inferolateral tooth; carpocerite usually reaching to or beyond end of scaphocerite.

Mouthparts without enlarged labrum. *Pars incisiva* of mandible never expanded nor bearing long teeth; *pars molaris* and palp always present; subsequent mouthparts as usual for family but with distal articles of third maxilliped bearing variously bristles or spines.

Chelae of first pair always asymmetrical in form and usually in size, never carried folded against merus. Large chela of variable form in the species, from smooth and sub-cylindrical to compressed and twisted with sculpturing of palm at times deep and strong. Dactylus with "plunger", a piston-like process on oppositive surface fitting into cavity on propodal pollex, usually well-developed, but at times reduced to slight confluent ridge; always with palmar and digital adhesive plaques. Large cheliped always with short, hemispherical carpus, with merus triangular in section. Small chela usually of simple form with conical fingers, but at times showing marked sexual dimorphism, at times with dactylus expanded and carrying dense setae on crests.

Carpus of second legs always with five articles of variable proportions.

Third and following legs robust, at times with merus triangular in section; armature and proportions of various articles variable; dactylus usually simple and conical, in some species biunguiculate, in others sub-spatulate. Fifth legs with "brush" distally on propodus.

Abdomen usually without lateral compression, with pleura in females larger than those of males, at times with acute projections on margins. Pleura of sixth abdominal segment not articulated. Endopod of second pleopods of males carrying an *appendix masculina* in addition to the usual *appendix interna*. Telson with posterolateral angles not projecting or acute, posterior margin arcuate and slightly projecting, neither indented nor projecting as a tooth; two pairs of dorsal spines. Anal tubercles almost always well-developed. Outer uropod almost always with distal articulation; inner uropod at times bearing short heavy spines on distal margin.

Branchial formula usually with five pleurobranchs, one arthrobranch, eight epipodites and at times a supplementary arthrobranch on third maxilliped.

DISCUSSION:

CHANGE FROM *CRANGON* TO *ALPHEUS*

For over 100 years almost all carcinologists used Fabricius' 1798 name to designate this genus (except for those who split off certain species to which they applied what are now considered to be junior synonyms, or simply mispelled the name — see Holthuis, 1955a). However, in 1904 M. J. Rathbun, the leader in carcinology in the United States,

published upon the names used in Weber's "Nomenclator entomologicus . . ." of 1795. She pointed out that both Weber and Fabricius had available to them unpublished manuscript copies of Daldorf's report on Asiatic crustaceans, and each had interpreted this manuscript in a different way. As Weber's publication had priority over that of Fabricius, she made changes in generic names in 7 cases. Concerning us here are only 2 changes in nomenclature: Weber had placed the species that Fabricius had earlier named as *Astacus malabaricus* in his new genus that he called *Crangon*. Fabricius, in his later publication, ignored Weber's work and created the genus *Alpheus* for *malabaricus* and other species, and *Crangon* for the Linnean species, *Cancer crangon*. All subsequent workers, until the Rathbun report, were either unfamiliar with Weber's work or chose to ignore it. By the principle of priority, Rathbun showed that the name *Alpheus* should be suppressed, the genus previously known as *Alpheus* should be called *Crangon*, and the commercially important genus known by the Fabrician name of *Crangon* must be given a new name, for which she chose *Crago* Lamarck.

Most Americans and some Australians followed Rathbun's lead while most Europeans ignored her changes for the next 50 years. It was the situation in which if the name *Crangon* was used in the scientific literature, one would have to know the nationality and the preferences of the author to determine if it was *Crangon*=*Alpheus* or *Crangon*=*Crago*. Finally, in 1955 the International Commission for Zoological Nomenclature, in Opinion 334, acting upon an application by L. B. Holthuis, used its plenary powers to suppress Weber's usages and to return as officially accepted the names *Alpheus* Fabricius and the family name Alpheidae. (We have not listed *Crangon* in synonymy except when a significant contribution to the knowledge of the species was made under that generic name; all citations from Australia made under *Crangon* have been listed in Appendix III.)

RELATED GENERA AND SPECIES

A number of genera were created for species once included in the genus *Alpheus*. The first major and single most important split was the creation of the genus *Synalpheus* by Bate in 1888; this genus, as redefined by Coutière (1899:334), is the second most important genus in terms of number of species within the family. It was dealt with in Part II of this study, and the characteristics for the separation of the two genera were there discussed.

Other new genera which now include members previously placed in *Alpheus*, or contain related species, are:

Pomagnathus Chace, 1937, created for a new American species, *P. corallinus* Chace;

Thunor Armstrong, 1949, created for *Alpheus rathbunae* Schmitt, an Atlantic species and once extended to include various Indo-Pacific species which were subsequently transferred back to *Alpheus* — see B&B, 1962: 162 *et seq.*

Metalpheus Coutière, 1908a, redefined by Chace, 1972 — see p. 280 for discussion.

SUBGENERIC GROUPS

Coutière (1899) divided the genus into "Groups" and later (1905a) divided one of the groups into three "Sub-Groups" which he was able to define and to which he applied the name of a characteristic species of the group, as the "Edwardsii Group". These groups were not given the name or status of subgenera, and lie beyond the International Rules of Zoological Nomenclature.

As new species that were added to the groups varied in this or that of the group

characteristic, all definitions of the groups became ambiguous. This was discussed in 1953 (B., p.47) and 1966b (B&B., p.75) — in this publication we elevated "sub-groups" to be coequal to the four original groups — and decided that while the groups could not be considered as subgenera they were of definite utility in the separation of the large number of species found within the genus. Apparently all other contemporary workers utilize these groups, some (as Crosnier and Forest, 1966) by formally dividing the species by "Group" captions, others by referring to the "Groups" in their discussions (Holthuis, 1951, Chace, 1972). We will also continue to use this aid to classification and will give a short characterization and notes before each group given below. We have followed the order of placement of the groups given by de Man. We have not been able to arrange the key so that the species within each group lie in sequence.

VARIATION IN THE GENUS *ALPHEUS*

Within this genus, as in *Synalpheus,* we find some species that are remarkably constant across the span of the Indo-Pacific realm, and others that vary markedly on the same coral reef. As with *Synalpheus,* we do not know how to handle this variability. In *A. collumianus* Stimpson for example, some 25 years ago we divided the specimens from the Marianas into three separate subspecies; in this paper we are eliminating the subspecific designations; similarly, we have found sufficient variation in *A. gracilis* Heller to believe that its three subspecies (or varieties) are not warranted. Variation is especially marked in the species in the Obesomanus Group that dwell as pairs in galleries under coralline algae and coral crust; fortunately with these the extent of variation can be determined by comparing the members of cohabiting pairs. On the other hand, very small characteristics in the sculpturing of the palm of the large chela such as the overhanging shoulder above the superior saddle in *A. pacificus* Dana, or its sharp prolongation in *A. chiragricus* Milne Edwards seem to be consistent throughout the entire range of the species.

Some few characteristics vary with maturity, especially the secondary sexual characteristics found in the small chela of males. Even this is not constant and recently we found we could separate *A. lobidens* de Haan into two apparently geographically separated subspecies upon whether the adult males showed the development of these sexual characteristics or not (B&B, 1975:429; see also below, p. 252). Other characteristics, especially highly modified characteristics like the hoof-shaped unguis of the third leg of *A. lottini* Guérin, may be slow in development (B, 1958:164). We are suggesting that a young rather aberrant specimen in the present collection may be the young of *A. novaezealandiae* Miers (p. 148).

With the variation that can be observed in many of the species, we have doubts as to whether some of the forms we have described below as new species or subspecies will continue to be considered as valid when greater collections are made of these and related species. We have taken the attitude that where in the related species a continuum of variation in a characteristic is seen and the differing form presents a slight to moderate extension of the continuum, it should not be described as new. On the other hand, where the extent of variation is not known in the described or related species, or where the new form shows a condition far beyond any variation previously reported, it should be described as new simply to facilitate dealing with it, as a named form, in the future literature.

NOTES ON SOME SPECIAL CHARACTERISTICS

"Balaeniceps" chela: As far as we have been able to determine, it was Coutière in

1899 who first used the word "balaeniceps" to describe the development of the small chela found in certain of the species of the genus, especially those in the Brevirostris and Edwardsii Groups. The word is obviously derived from the Latin *balaena,* the name of the baleen whales, and the Latin *caput,* head, and refers to a fringe of setae that apparently reminded Coutière of the rows of whalebone in a cetacean's mouth*. In the most extreme form, the dactylus of the small chela is broadened and somewhat excavate on the oppositive face and bears a row of regularly placed stiff setae on a low ridge starting on the lateral face near the articulation and proceeding distally; towards the tip, but short of it, the setiferous crest withdraws from the margin of the fingers and crosses over the superior surface to proceed proximally to near the dactylar articulation on the medial face (see Fig. 75, e, f, g). The fringe demarks an area on the superior face that is approaching triangular. Beyond the fringe of setae the tip of the dactylus usually extends as a curved, heavy and acute tooth. This is usually a sexually dimorphic characteristic and is found in mature males, with the immature males and usually the mature females usually bearing only simple conical fingers.

Not all species, even when mature, bear this extreme condition. Instead, the completely befringed dactylus may show lesser degrees of lateral expansion down to a narrow and tapering article (*cf.* figs. 77f and 79f). To this condition we still apply the term "balaeniceps". If, however, only the medial and lateral faces of the chela bear the characteristic rows of setae, but they are not continuous over the superodistal portion, we apply the term "sub-balaeniceps" (fig. 70e). If a setiferous crest is found on only one side of the dactylus, we have not applied either term (fig. 60f). The term does not refer to a generalized setiferous condition, nor to the existence of tufts or bunches of setae (fig. 57f).

Plunger and socket of large chela: Characteristically in the genera *Racilius, Synalpheus, Alpheus* and *Metalpheus,* the dactylus of the large chela bears a somewhat cylindrical "plunger" that rests in a concavity in the fixed finger, or pollex, when closed. On the superoproximal surface of the dactylus, and on the distal end of the upper palmar surface, there are two "adhesive plaques", circular areas of extremely smooth chitin. The two plaques adhere when the chela is opened and, with the straining of the large muscles found in the palm, the adhesive bond is finally broken and the plunger is shot into the socket with such force as to make the characteristic clicking sound that gives the shrimp their common name, "snapping" or "pistol" shrimp. This production of sound and the use of the mechanism in the shrimp's behaviour has often been discussed in the literature (for example, Knowlton and Moulton, 1963:311, 20 figs.; Pope, 1949:326, 3 figs.; Ritzmann, 1973:459, 2 figs. According to Dr F. A. Chace Jr., judging from sketch of the chela (fig. 2a) the species discussed in Ritzman's paper "is not *Alpheus californiensis*" [personal communication].)

The characteristics of this plunger have seldom been used for specific separation within the genus. Early in our study of this genus we were struck by how the apparatus varied between species. For example, it is lacking entirely in *A. hailstonei* Coutière, and is developed as a triangular tooth without an opposing socket in the related *A. crockeri* (Armstrong). Of those that have the plunger-socket apparatus (fig. 4) there are some, like *A. pacificus* Dana that have a massive plunger, with height about half of that of maximum height of the dactylus (when seen in side view) and with its margins set off abruptly from axis of the dactylus at an angle of about 115°. In *A. lottini* the plunger is about one-third

*Dr F. A. Chace Jr. of the Smithsonian Institution has suggested in a letter to us that Coutière might not have been comparing the fringe of setae to the baleen, but rather the "triangular boss between the rows of setae on the extensor surface of a balaeniceps dactyl" to the "beak" of a whalebone whale when seen from above.

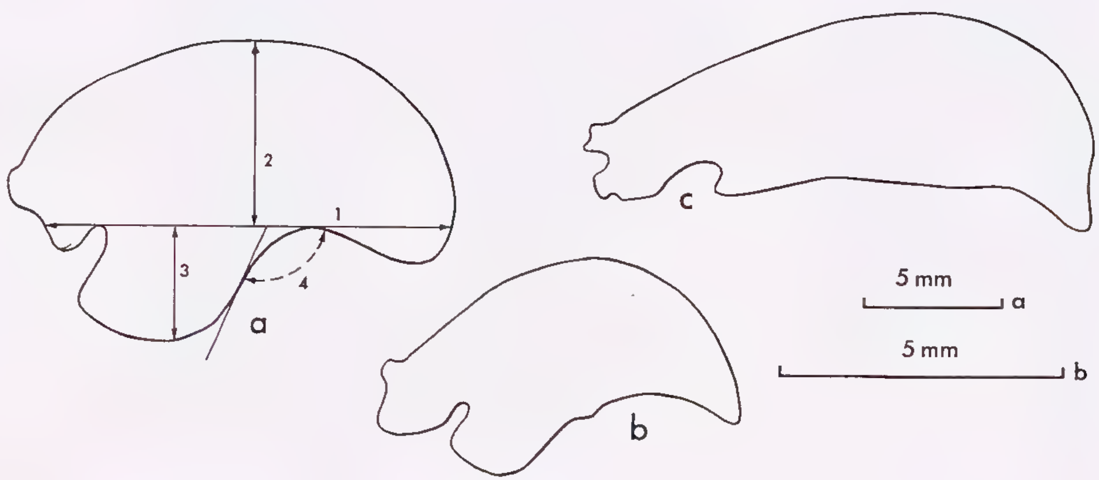

Fig. 4 Examples of dactyli of large chelae in the genus *Alpheus*
a. *A. pacificus* Dana from AM P. 13574, illustrating measurements taken: 1 axis of dactylus and total length; 2 height of dactylus; 3, height of plunger; 4, angle of plunger; **b.** *A. lottini* Guérin, from AM P. 10322; **c.** *A. distinguendus* De Man from UQ 28. c. Scale a; a, b scale b.

the height of the dactylus and the angle is about 130°. Finally, in *A. distinguendus* de Man the plunger is a low crest, usually between 0.1 and 0.2 the height of the dactylus and making an angle of about 165° to the axis of the dactylus, but with its margin gradually curving into the margin of dactylus distally (we term this condition as "confluent"). In *A. pacificus* and *A. lottini* the socket in the pollex is a definite circular hole, but in *A. distinguendus* it is an elongate groove. In all three species the proximal edge of the plunger is abrupt.

We decided to explore the validity of this characteristic for separation in the species by drawing and measuring a total of 108 specimens from *A. distinguendus* de Man, *A. chiragricus, A. edwardsii* (Audouin). *A lottini, A. euphrosyne euphrosyne* de Man, *A. euphrosyne richardsoni* Yaldwyn and *A. pacificus* (listed in order of plunger development). We derived ratios of plunger height to dactylar height, plunger height to dactylar length and the angle of the plunger to the axis of the dactylus (fig. 4a); these ratios were studied in reference to the size and sex of the specimens.

We found that while most of the specimens were grouped there was always a spread in each characteristic; for example in 18 specimens of *A. pacificus* the ratios of plunger height to dactylar height fell between 5.0 and 5.9, but 2 were between 3.0 and 3.9. The two aberrant specimens could not be separated on size or sex differences. Regretfully we concluded that the size, shape and angle of the plunger was of systematic value only in its extremes — thus never did the condition in *A. distinguendus* overlap that of *A. pacificus*, but these were not of diagnostic value, except in a general way, between species like *A. edwardsii* and *A. lottini*. We, therefore, have had to content ourselves with the vague and unquantified description of the plunger as "low and confluent", "of moderate development" and "heavy and at a marked angle". So described, the characteristic may be of some aid.

A STUDY ON TASMANIAN ALPHEIDS

After we had completed the manuscript of this portion of the study we were asked by the University of Tasmania to be an outside reviewer for the doctoral thesis of Ms Khin Khin U, entitled "On the biology of *Alpheus richardsoni* Yaldwyn 1971". To date the thesis, in whole or in part, has not been published, but we have Ms U's permission to cite it. She has reported four species of alpheids from Tasmanian waters: *A. richardsoni* Yaldwyn and *A. novaezealandiae* Miers, both of which we are also reporting from Tasmania *(A. richardsoni* as *A. euphrosyne richardsoni); A. crockeri* (Armstrong), a widespread tropical alpheid that we did not find in any of the Australian or Tasmanian collection; and a new species (to which she assigned a manuscript name). She also discussed the distribution of these four species in Tasmania. We will indicate the two species we did not find in our collections in the key only by footnote as we have not seen the specimens and the records have not been published. For *A. e. richardsoni* she has presented a detailed series of observations on its general biology based both on field notes and laboratory studies; some of these we have summarized under the subspecies (p. 239).

KEY TO THE SPECIES OF THE GENUS *ALPHEUS* IN AUSTRALIAN WATERS*

1.		Large chela with at most a depressed area on lower margin, never with a shoulder; where a transverse groove occurs proximal to dactylar articulation, usually the groove not U-shaped nor leading to depressed area	2
	—	Large chela with definite shoulder on inferior margin proximal to base of fixed finger; superior margin bearing transverse U-shaped groove proximal to dactylar articulaton that usually expands into broadened depressed areas on either face	52
2.	(1)	With acute teeth on anterior portions of orbital hoods or margins between hoods and rostrum	3
	—	Neither anterior orbital hoods nor orbitorostral margins with teeth, but orbital hoods may bear anterior keels or posterior teeth	17
3.	(2)	Dactylar articulation of large chela always flanked with strong, acute tooth on lateral side, usually on medial side as well; palm always with heavy longitudinal sculpturing	4
	—	Dactylar articulation of large chela without flanking acute teeth; if palm longitudinally sculptured, crests and groove not heavy	8
4.	(3)	Orbitorostral grooves short and slight, or absent........	5
	—	Orbitorostral grooves definite and extending to behind eyes	7
5.	(4)	Crest on large chela leading to medial tooth of dactylar articulation not interrupted** ....*A. astrinx* (p. 35)	
	—	Crest of large chela leading to medial tooth of dactylar articulation abruptly interrupted by transverse groove	6
6.	(5)	Second antennular article 4 times as long as broad; dactylus of large chela curved and extremely compressed........*A. hailstonei* (p. 38)	
	—	Second antennular article about twice as long as broad; dactylus of large chela straight and moderately compressed........?*A. staphylinus* (p. 41)	
7.	(4)	Inner side of both chelae with setae so heavy as to almost obscure outlines........*A. deuteropus* (p. 42)	
	—	Inner side of both chelae with only scattered setae....*A. collumianus* (p. 45)	
8.	(3)	Rostral base between eyes gradually curving into orbitorostral grooves	9
	—	Rostral base between eyes abruptly set off from orbitorostral grooves, at times overhanging them........	14

* One specimen of the genus *Alpheus* has been left unnamed in this paper; A. species, possibly an immature form of *A. novaezealandiae* (see p. 148) was too incomplete to treat in this key. *A. collumianus* Stimpson varies so much in the characteristics used in dichotomy 2 that it is keyed out under both branches.

**Into this part of the dichotomy falls *A. crockeri* (Armstrong) 1941 which was reported by U from Tasmania (ms. 1977:33; see our p. 24).

9. (8) Large chela with superior surface papillose and medial face somewhat or heavily hirsute 10

— Large chela with superior surface smooth and medial face bearing at most scattered setae 11

10. (9) Carapace densely covered with short setae; with teeth on both orbital hoods and orbitorostral margins .... *A. villosus* (p. 49)

— Carapace glabrous; with teeth only on orbital hoods ... *A. architectus* (p. 55)

11. (9) Rostral carina behind eyes carrying two forward-directed teeth .... *A. cristatus* (p. 122)

— Rostral carina without any trace of teeth 12

12. (11) Meri of both chelipeds without movable spines; orbital teeth arising from anterodorsal surface of hoods, not margins .... *A. splendidus* (p. 56)

— Meri of both chelipeds armed with spines; orbital teeth arising from margin of hoods 13

13. (12) Large chela with slight transverse depression on superior margin; no longitudinal crest; frontal margin between orbital hoods and rostrum recessed .... *A. gracilis* (p. 60)

— Large chela without transverse depression, with slight superior longitudinal crest; frontal margin between orbital hoods and rostrum produced into a convex prominence .... *A. facetus* (p. 62)

14. (8) Large chela entire, without sculpturing; dactylus of third legs with blunt, rounded tip .... *A. lottini* (p. 65)

— Large chela with sculpturing; dactylus of third leg either simple or biunguiculate, but acute 15

15. (14) Large chela with only a transverse groove; dactylus of third leg simple .... *A. bicostatus* (p. 124)

— Large chela with or without transverse groove, but with longitudinal grooves; dactylus of third legs biunguiculate* 16

16. (15) Second article of third maxilliped expanded distally into marked lobe .... *A socialis* (p. 68)

— Second article of third maxilliped only slightly expanded distally .... *A parasocialis* (p. 72)

17. (2) With heavy, acute teeth flanking dactylar articulation of large chela .... *A. collumianus* (p. 45)

— Without acute teeth flanking dactylar articulation of large chela 18

*Under this couplet comes *A. sp. nov.* U (ms. 1977:17; see our discussion p.24); it apparently may be distinguished from both *A. socialis* and *A. parasocialis* by the smooth rather than pustulate faces of both chelae.

18. (17) Large chela rounded or at most slightly compressed in section, entire or with slight sculpturing.. 19

— Large chela, if rounded in section, with definite grooves; otherwise, laterally compressed, with or without sculpturing............................ 35

19. (18) Dactylus of large chela either tapering to tip, or heavy and rounded, but not in shape of a double-headed hammer 20

— Dactylus of large chela in form of a rounded double-headed hammer, with depression on superior margin of palm to accommodate superior head of dactylus when flexed... 33

20. (19) First carpal article of second legs equal in length to or longer than second 21

— First carpal article of second legs about half as long as second article, or less... 27

21. (20) Merus of large cheliped with heavy, acute subterminal tooth on inferior internal margin 22

— Merus of large cheliped with or without terminal tooth on inferior margin, never with tooth located subterminally................................ 23

22. (21) Fingers of small chela about twice length of palm...............*A. labis* (p. 127)

— Fingers of small chela equal to length of palm..........*A paracrinitus** (p. 129)

23. (21) Rostrum strong, acute.. 24

— Rostrum absent, or very small obtuse triangle.................................. 26

24. (23) Frontal margin of carapace with slight flattened projection on anteromedial side of orbital hoods; superior margin of large chela with slight, ill-defined oblique depression............................*A. ehlersii* (p. 132)

— Frontal margin of carapace not projecting; large chela without depressions 25

25. (24) Large chela about 2.3 times as long as broad; merus of third leg 3 times as long as broad; propodus of third leg bearing 10-12 spinules ....*A. ovaliceps* (p. 98)

— Large chela about 3 times as long as broad; merus of third leg 5 times as long as broad, propodus of third leg bearing 6 spinules.......*A mitis* (p. 134)

26. (23) Anterior margin of carapace extending beyond orbital hoods as rounded, shelf-like projection, without rostrum; merus of third leg without tooth ....*A. frontalis* (p. 99)

— Anterior margin of carapace not extending beyond orbital hoods, bearing a minute rostrum in form of obtuse triangle; merus of third leg with acute tooth...*A. pachychirus* (p. 102)

* Elsewhere in the Indo-Pacific this species is variable in many characteristics including those given in dichotomies 20 and 21.

27. (20) Anterior margin of carapace projecting beyond orbital hoods; palm of small chela somewhat bulbous 28

— Anterior margin of carapace (except for rostrum) not projecting beyond orbital hoods; palm of small chela not bulbous and with at most a slight taper 29

28. (27) Interorbital carina a high crest; sixth abdominal tergum bearing a pair of teeth at margins of articulation of telson .... *A. eulimene* (p. 105)

— Interorbital carina low; tergum of sixth abdominal segment bearing 3 teeth overhanging anterior part of telson .... *A. arethusa* (p. 110)

29. (27) Orbital hoods anteriorly with vertical keel; orbitorostral grooves deep and well defined .... *A. amirantei sizou* (p. 74)

— Orbital hoods rounded anteriorly; orbitorostral grooves shallow and rounded at most 30

30. (29) Carpus of third legs with 2 or more spines 31

— Carpus of third legs without spines 32

31. (30) Merus of third legs bearing a series of spines .... *A. alcyone* (p. 110)

— Merus of third legs without spines .... *A. paralcyone* (p. 113)

32. (30) Squame of scaphocerite vestigial; merus of third legs with regular series of long setae .... *A. spongiarum* (p. 116)

— Squame of scaphocerite normal, reaching near end of antennular peduncle; merus of third legs almost glabrous .... *A. bucephalus* (p. 120)

33* (19) Tip of telson narrow, straight and flanked with heavy and long spines .... *A. obesomanus* (p. 89)

— Tip of telson broad, arcuate and bearing light spines on posterolateral angles 34

34. (33) Scaphocerite not overreaching second antennular article; second carpal article less than twice as long as first .... *A. malleodigitus* (p. 92)

— Scaphocerite overreaching second antennular article; second carpal article at least twice as long as first .... *A. microstylus* (p. 92)

35. (18) Large chela oval to rounded compressed in section; with sculpturing. 36

— Large chela compressed, quadrangluar in section, often with definite ridges separating the 4 faces; sculpturing variable 42

36. (35) Large chela with dense and conspicuous setae, especially on inner face; with faint to conspicuous longitudinal groove near middle of outer face 37

* The species in dichotomies 33 and 34 are extremely variable; before final determination as to species is made, refer to the discussion under the Obesomanus Group, (p. 87).

— Large chela bearing at most scattered setae on inner face; without longitudinal grooves near middle of outer face 39

37. (36) Merus of third legs with strong tooth; first carpal article of second leg about one-third length of second ....*A. acutofemoratus* (p. 77)

— Merus of third legs unarmed; first carpal article of second leg approximately equal to or longer than second 38

38. (37) Rostrum short, reaching about middle of first antennular article, and bearing stiff, upstanding setae on margins; first carpal article of second legs slightly longer than second.................................*A. sulcatus* (p. 79)

— Rostrum reaching to near end of first antennular article and without setae on margin; first carpal article of second legs about twice length of second ....*A. australosulcatus* (p. 83)

39. (36) With conspicuous flattened teeth mesad of posterior portions of orbital hood .... *A. bidens* (p.136)

— Dorsal surface of carapace not bearing teeth 40

40. (39) Merus of third legs with strong, somewhat subterminal tooth ....*A. diadema* (p. 140)

— Merus of third legs without tooth.. 41

41. (40) Palm of large chela uniformly rounded-oval; transverse groove proximal to dactylar articulation rather broad, U-shaped ....*A. gracilipes* (p. 143)

— Lower outer margin of palm of large chela sharp and separated from outer face by rounded longitudinal depression; transverse groove proximal to dactylar articulation narrow, V-shaped ellipses ....*A. novaezealandiae* (p. 145)

42. (35) Without transverse groove proximal to dactylar articulation of large chela 43

— With slight to pronounced transverse groove proximal to dactylar articulation of large chela 46

43. (42) Large chela over six times as long as broad; mid-dorsal carina interrupted posterior to orbital hoods ....*A. acutocarinatus* (p. 151)

— Large chela at most 4.5 times as long as broad; mid-dorsal carina, if present, not interrupted.. 44

44. (43) Carapace not smooth but pustulate, especially anterior regions ....*A. stephensoni* (p. 153)

— Carapace smooth 45

45. (44) Palm of small chela of male as long as broad, of female slightly longer than broad; fingers of small chela of male approaching three times length of palm ....*A. distinguendus* (p. 157)

— Palm of small chela of both sexes twice as long as broad; fingers of small chela about twice length of palm................................*A. rapacida* (p. 160)

46. (42) Dactylus of third leg simple, conical 47

— Dactylus of third leg expanded, subspatulate 49

47. (46) Rostrum short, obtusely triangular, not reaching beyond orbital hoods; fingers of small chela of both sexes with dense setae on inner face .... *A. barbatus* (p. 163)

— Rostrum acute, reaching middle of first antennular article or beyond; small chela at most with only balaeniceps fringe on dactylus 48

48. (47) Carapace with light pubescence; dactylus of small chela of male with balaeniceps fringe of setae .... *A. pubescens* (p. 167)

— Carapace glabrous; small chelae not sexually differentiated and with only few setae .... *A. miersi* (p. 168)

49. (46) Mediodistal face of palm of large chela smooth; small chela of male not balaeniceps, fingers about twice as long as palm. 50

— Mediodistal face of palm of large chela granular; small chela of male sub-balaeniceps or balaeniceps, fingers up to 1.3 times as long as palm. 51

50. (49) Both fingers of small chela of male excavate only on medial face .... *A. brevirostris* (p. 170)

— Dactylus of small chela of male arched on both margins to leave the fingers gaping when closed.. *A. rapax* (p. 174)

51. (49) Rostral carina continued to mid-carapace; second article of third maxilliped with only short setae; small chela of male balaeniceps .... *A. moretensis* (p. 177)

— Rostral keel continued only to posterior portion of orbital hoods; second article of third maxillipeds with tuft of long setae; small chela of male sub-balaeniceps .... *A. djiboutensis* (p. 180)

52. (1) With projecting acute tooth on distoinferior margin of merus of third leg. 53

— With distoinferior margin of merus of third leg at most angular 58

53. (52) With lateral tooth of basicerite reaching to level of middle of second antennular article .... *A. parvirostris* (p. 185)

— With lateral tooth of basicerite not reaching to end of first antennular article 54

54. (53) Proximal shoulder of superior saddle of large chela not overhanging groove 55

— Proximal shoulder of superior saddle of large chela overhanging groove. 56

55. (54) Second carpal article of second legs about 1.2 times length of first; rostrum slender .... *A. edamensis* (p. 188)

— Second carpal article of second legs about half the length of the first; rostrum approaching an equilateral triangle............ *A. hutchingsae* (p. 191)

56. (54) Fingers of small chela excavate, dactylus without longitudinal crests .... *A. hippothoe* (p. 193)

— Fingers of small chela not excavate; medial face of dactylus with longitudinal crest, crest at times setiferous 57

57. (56) Crest on medial face of dactylus of small chela of male setiferous; spines on propodus of third leg in double row........................*A. serenei* (p. 196)

— Crest on medial face of dactylus of small chela of male not setiferous; spines on propodus of third legs in single row..............*A. georgei* (p. 200)

58. (52) Neither male nor females with balaeniceps crests of hairs on dactylus of small chela*.. 59

— With male only or with both sexes bearing balaeniceps crests of hair on dactylus of small chela 66

59. (58) With acute terminal or subterminal tooth on inferointernal margin of merus of large cheliped 60

— With inferointernal margin of merus of large cheliped unarmed......... 63

60. (59) Dactylus of third legs conical 61

— Dactylus of third legs triangular to broadened and subspatulate......... 62

61. (60) Orbitorostral margin projecting as small shelf; orbital hoods without setae; superior saddle of large chela slight and poorly defined ....*A. maindroni* (p. 203)

— Orbitorostral margin not projecting; anterior margin of orbital hoods bearing one conspicuous hair; superior saddle of large chela broad and definite ....*A. dolerus* (p. 205)

62. (60) Rostral triangle short, scarcely reaching beyond orbital hoods and almost as broad as long; plunger of dactylus of large chela low and gradually curving into distal margin of article..............*A. malabaricus trefzae* (p. 207)

— Rostral tip reaching well beyond orbital hoods and almost twice as long as broad at base; plunger of dactylus of large chela heavy and set off from distal margin of dactylus ....*A. macrodactylus* (p. 210)

63. (59) Proximal shoulder of superior saddle of large cheliped not overhanging floor of groove... 64

— Proximal shoulder of superior saddle of large cheliped definitely overhanging floor of groove 65

64. (63) Both inferior shoulder and shoulder proximal to superior saddle low and rounded in profile ....*A. bunburius* (p. 213)

— Both inferior and superior shoulders heavy, abrupt and subrectangular in profile ....*A. tasmanicus* (p. 215)

65. (63) Lower shoulder on lateral face of large chela with deep rounded notch distally; plunger on dactylus very heavy and at marked angle to distal dactylar margin...*A. pacificus* (p. 217)

*Three species or subspecies in this dichotomy are known only from the female and therefore will be keyed under both choices; they are *A. bunburius, A. heronicus* and *A. malabaricus trefzae*.

— Lower shoulder on lateral face of large chela not set off from more distal margin of pollex by notch; plunger of dactylus low and confluent with distal margin..*A. heronicus* (p. 220)

66. (58) Both males and females with balaeniceps or sub-balaeniceps dactylus on small chela 67

— Males only with balaeniceps dactylus on small chela........................ 71

67. (66) Shoulder proximal to superior saddle of large chela low and rounded 68

— Shoulder proximal to superior saddle abrupt and at times overhanging floor of groove.. 69

68. (67) Merus of both chelipeds without a distal tooth; plunger of dactylus of large chela heavy and at marked angle to distal margin. ....*A. australiensis* (p. 256)

— Merus of both chelipeds bearing a distal tooth on inferointernal margin; plunger of dactylus low and confluent with distal margin. (Note: female alone known but male presumed to have a balaeniceps dactylus.) ....*A. balaenodigitus* (p. 223)

69. (67) Proximal shoulder of superior saddle of small chela of both sexes abrupt, at right angles or overhanging floor of groove; plunger of dactylus of large chela low and confluent with distal margin ....*A. pareuchirus imitatrix* (p. 278)

— Proximal shoulder of superior saddle of small chela of both sexes low and rounded; plunger of dactylus of large chela heavy and set off at marked angle from distal margin... 70

70. (69) Inferior margin of small chela of both sexes almost straight, without trace of shoulder...*A. strenuus strenuus* (p. 225)

— Inferior margin of small chela of both sexes with marked but low shoulder ....*A. strenuus cremnus* (p. 229)

71. (66) Proximal shoulder of superior saddle of large chela rounded to abrupt, not overhanging groove 72

— Proximal shoulder of superior saddle of large chela rounded to acute and overhanging floor of groove 79

72. (71) Dactylus of third leg somewhat flattened to definitely subspatulate 73

— Dactylus of third leg simple and conical 76

73. (72) Propodus and dactylus of third leg bearing setae on lateral face; plunger of dactylus of large chela heavy and at marked angle to distal margin . 74

— Propodus of third leg with setae only on margins, dactylus glabrous; plunger of dactylus of large chela low and confluent with distal margin 75

74. (73) Squamous portion of scaphocerite broad and reaching near end of lateral tooth; small chela of mature males with superior saddle ....*A. euphrosyne euphrosyne* (p. 232)

— Squamous portion of scaphocerite narrow, not reaching near end of

lateral tooth; small chela of mature males without trace of superior saddle...*A. euphrosyne richardsoni* (p. 235)

75. (73) Rostrum reaching only slightly beyond margins of orbital hoods; merus of large chela unarmed; dactylus of third leg subspatulate ....*A. malabaricus trefzae* (p. 207)

— Rostrum reaching well beyond margins of orbital hoods; merus of large chela with small sub-terminal tooth; dactylus of third legs trigonal with expanded and flattened inferior surface....................*A. bunburius* (p. 213)

76. (72) Inner face of small chela of male with heavy setae in distal half or on fingers alone.. 77

— Inner face of small chela of male with only scattered setae (except for the balaeniceps fringe) 78

77. (76) Small chela of male with heavy sculpturing; setae scattered on distal half of inner face of male and female small chelae ....*A. inopinatus** (p. 241)

— Palm of small chela of male rounded, without sculpturing; dense setae only on inner face of fingers of male small chela ....*A. sudara* (p. 243)

78. (76) Superior saddle of large chela extending into lateral face as narrow U-shaped groove; mature males with little sculpturing on palm of small chela ....*A. leviusculus leviusculus* (p. 246)

— Superior saddle of large chela extending into a well-marked triangular depression; small chela of mature males with heavy sculpturing ....*A. lobidens lobidens* (p. 252)

79. (71) Inferior shoulder on outer face of large chela projecting into an acute subacute tooth... 80

— Inferior shoulder on outer face of large chela rounded 83

80. (79) Inferior shoulder of outer face of large chela bearing numerous small papillae...*A. papillosus* (p. 260)

— Inferior shoulder of outer face of large chela smooth 81

81. (80) Rostrum and rostral triangle on carapace flattened dorsally, sharply demarked and overhanging orbitorostral grooves ....*A. bisincisus* (p. 263)

— Rostrum and rostral triangle rounded dorsally and curving into orbitorostral grooves 82

82. (81) Proximal shoulder of superior saddle and inferior shoulder of outer face of large chela projecting as acute teeth; rostrum narrow, and awl-shaped...*A. chiragricus* (p. 267)

— Proximal shoulder of superior saddle and inferior shoulder projecting as rounded teeth; rostrum broader, triangular. (Note: this species shows a marked variation in sculpturing of large chela — see fig. 83 l, m, n.) ....*A. edwardsii* (p. 270)

83. (79) Dactylus of third leg biunguiculate...............................*A. polyxo* (p. 274)

*Species no longer considered valid — see footnote, (p. 241).

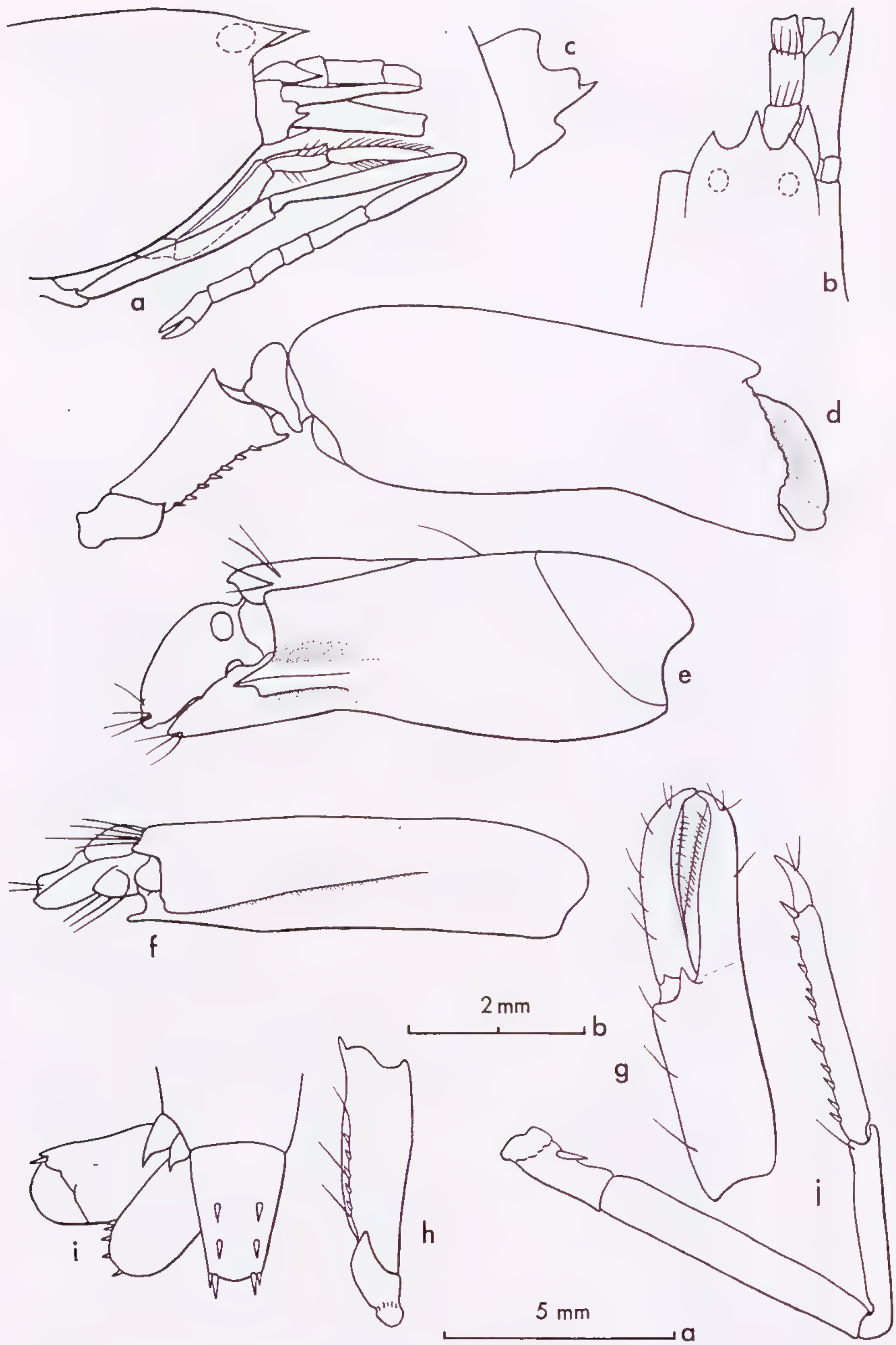

Fig. 5 *Alpheus astrinx* sp. nov.
Holotype (female). **a, b.** Anterior region, lateral and dorsal view; **c.** basicerite, enlarged; **d.** large cheliped, medial face; **e.** large chela, lateral face; **f.** large chela, superior face; **g, h.** small chela, lateral face and merus, medial face; **i.** telson and uropods. 40 mm female paratype; **j.** Third leg. a, b, d, e, f, g, h, i scale a; c scale b.

— Dactylus of third leg simple 84

84. (83) Meri of both chelipeds unarmed; inner face of small chela and carpus of third leg with many long setae (only female known) ....*A. heronicus* (p. 220)

— Meri of both chelipeds armed with teeth; no conspicuous setae on small chela, except for balaeniceps fringe on finger of male, nor on carpus of third leg except at tip ....*A. pareuchirus pareuchirus* (p. 276)

MACROCHELES GROUP

Always with orbital teeth. Palm of large chela compressed, somewhat twisted, with 3 heavy longitudinal ridges and grooves, at times interrupted, terminating distally in (1)a heavy tooth above dactylar articulation, (2) the adhesive plaque, (3)a usually heavy tooth below the dactylar articularion; dactylus frequently high and thin, at times with bulbous tip. Small chela never balaeniceps. Third leg with or without meral tooth; dactylus biunguiculate or simple.

Many of the species of this group are only known from dredgings in deeper waters; the ones occurring intertidally or subtidally seem to be characteristic of clean habitats associated with growing coral.

Alpheus astrinx sp. nov.

Fig. 5

HOLOTYPE: 28 mm female from Garden Island, near Perth, W.A. 100 yds. offshore. Coll. R. Dawson and Marine Group, 25/11/61. In coral. (WM 265-65)

PARATYPES: 2 females and 2 males reaching to 43 mm in length collected from same locality as type (most without legs attached).

DIAGNOSIS: Rostrum acute, a little longer than broad at base, reaching to near end of first antennular article, rounded dorsally and separated from anterior portions of orbital hoods by only slight rounded concavities. At level of corneas carapace rounded with orbital hoods and rostral base confluent, not demarked. Orbital teeth acute, directed forward, one-third as long as rostrum, with medial margins joining base of rostrum as a continuous curve. Antennules stout; visible part of first antennular article slightly shorter than second article which is 1.5 times as long as broad; third antennular article 0.6 as long as second. Stylocerite acute, reaching to end of first antennular article. Squamous portion of scaphocerite narrow, not reaching to end of antennular peduncle, lateral margin straight, lateral tooth strong, reaching past end of antennular peduncle. Carpocerite stout, reaching to end of antennular peduncle. Lower margin of basicerite with acute tooth; adjacent to tooth is a rounded projection which blends gradually into distal margin.

Ratio of articles of third maxilliped: 10:4:7.

Large chela compressed, 3 times as long as broad with fingers one-quarter of total length. Proximal superior margin of palm curving laterally to form rounded ridge terminating in palmar adhesive plaque; distal portion of ridge demarked superiorly by flattened area, inferiorly by rounded groove. Superior flattened area with distal ridge on medial margin terminating in strong tooth flanking dactylar articulation. Distal portion of outer face with third longitudinal rounded ridge that terminates as lateral tooth flanking dactylar articulation; below this ridge is a rounded but deep depression. Dactylus bulbous and truncate at tip, medial face somewhat concave; plunger low, but fitting into well-defined open-ended groove on pollex. Merus twice as long as broad, superodistal

margin slightly projecting; inferointernal margin bearing several small spines and an acute tooth distally.

Small chela of female 4 times as long as broad with fingers as long as palm. Palm bearing an acute tooth on either side of articulation of dactylus. Superior margin of dactylus rounded; cutting edges of fingers bearing row of short stiff setae. Merus similar to that of large chela but slender, 3.5 times as long as broad. Small chela of male unknown.

Carpal articles of second leg with ratio: 10:5.4:3.3:3.3:4.0.

Ischium of third leg armed with spine. Merus inermous,.7 times as long as broad. Carpus 0.6 as long as merus, superodistal margin projected as a rounded tooth, inferodistal margin bearing one strong seta. Propodus 0.8 as long as merus, bearing on inferior margin 11 spines and a pair distally. Dactylus simple with slight notch on dorsal surface from which springs 2 short stiff setae. (This is a description from a third leg of a 43 mm paratype; the holotype had only the second leg).

Telson 2.6 times as long as posterior margin is broad; tip slightly arcuate; inner spine of posterolateral pair twice as long as outer. Anterior pair of dorsal spines placed anterior to middle.

DISCUSSION: The crests and grooves of the large chela plainly place this species in the Macrocheles Group. This species is related to the group of species in the Macrocheles Group that have no distoinferior tooth on the merus of the third leg. These include: *A. waltervadi* Kensley, *A. seurati* Coutière, *A. albatrossae* (Banner), *A. oahuensis* (Banner), *A. hailstonei* Coutière, *A. lanceostylus* Banner, *A. staphylinus* Coutière and *A. crockeri* (Armstrong). It can be separated from the first seven species by the lack of a transverse groove on the superomedial crest of the large chela. It can be further separated from *A. waltervadi, A. seurati* and *A. oahuensis,* all of which have a biunguiculate dactylus on the third leg. *A. hailstonei* usually carries a biunguiculate dactylus on the third leg, but this may by simple. *A. astrinx* is remarkably close to *A. crockeri,* but the form of the dactylus of the large chela is entirely different. In *A. astrinx* the dactyl is only a little compressed and lacks a strong superior keel while in *A. crockeri* the middle section of the dactylus is highly compressed, knifelike with a sharp superior keel. The tip of the dactylus in the present species curves inward only slighlty, but in *A. crockeri* the tip is broadly flared and extremely twisted. The cutting margin in *A. astrinx* bears a small but definite plunger or crest that fits into a concavity on the pollex in the typical *Alpheus* fashion, but in *A. crockeri* the plunger is developed as a heavy acute tooth which closes close to, but not against, a more rounded tooth on the basal portion of the outer face of the pollex (see Banner, 1953:19d, as *Crangon tuthilli*) and the pollex carries no socket or groove for its accommodation.

A crockeri is a widespread species, not uncommon in the central Pacific where it reaches to Hawaii; in the western Pacific it is known from the Gulf of Thailand as well as the Indian Ocean side of the Malayo-Thai peninsula. Crosnier and Forest (1965b:603) have reported it from the tropical Atlantic. However, it has never been reported from Australia, so *A. astrinx* may represent a stock in Australian waters derived from the more widespread *A. crockeri.*

The name is taken from the Greek *a,* without, and *strinx* meaning furrow, channel or groove and refers to the fact that the large chela lacks the transverse groove found in related species. The holotype and paratypes will be placed in the Western Australian Museum.

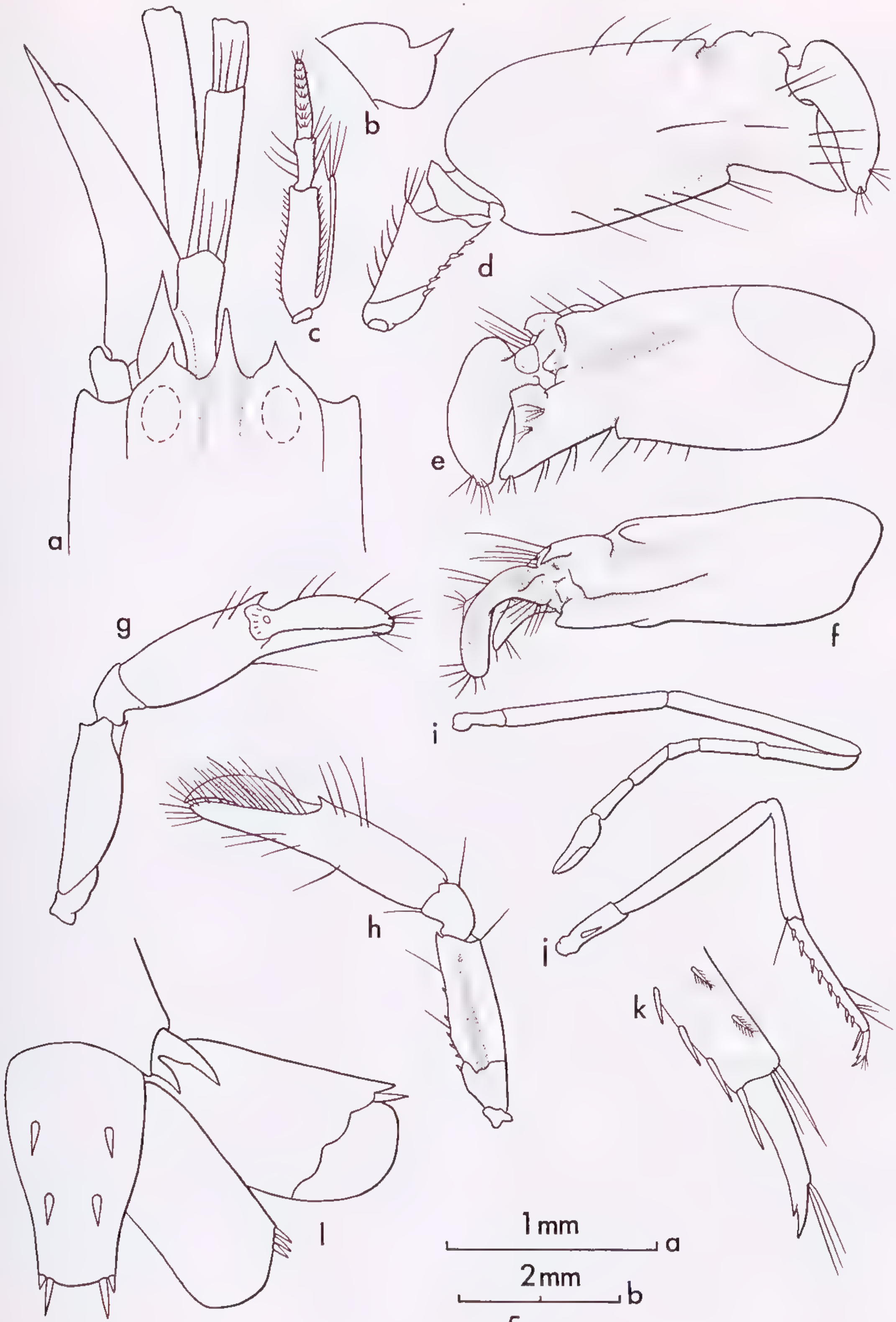

Fig. 6 *Alpheus hailstonei* Coutière
25 mm male from WM 184-65. **a.** Anterior region, dorsal view; **b.** basicerite; **c.** third maxilliped, medial face; **d.** large cheliped, medial face; **e, f.** large chela, lateral and superior face; **g, h.** small cheliped, lateral and medial face; **i.** second leg; **j, k.** third leg and dactylus enlarged; **l.** telson and uropods. d, e, f, g, h, i, j scale a; a, b, c, 1 scale b; k scale c.

Alpheus hailstonei Coutière
Fig. 6

Alpheus hailstonei Coutière, 1905a:879, pl. 74, fig. 18.
Alpheus hailstonei laetabilis De Man, 1908:98; 1911:333, fig. 64d.
Alpheus hailstonei assimulans De Man, 1908:99; 1911:331, fig. 64-64c. Miya, 1974:116, pl. 18.

Crangon hailstonei paucispinata Banner, 1953:51, fig. 16.

SPECIMENS EXAMINED: 1 specimen from AM G. 2190; 1, AMP. 7224; 3, AM P. 7377; 1, AM P. 7557; 1 AM P. 9448; 1, WM 45-65; 1 WM 63-65; 2, WM 64-65; 1, WM 69-65; 4, WM 71-65; 3, WM 90-65; 11, WM 94-65; 2, WM 132-65a; 1, WM 145-65; 14, WM 184-65; 2, WM 213-65; 2, WM 246-65; 2, WM 255-65; 5, WM 270-65; 2, WM 4985.

DIAGNOSIS: Rostrum acute, 1.5 times as long as broad at its base, reaching to middle of visible part of first antennular article. Visible part of antennular article 0.8 as long as second article, second article 4 times as long as broad, third article 0.4 as long as second. Stylocerite acute, reaching near end of first antennular article. Scaphocerite with lateral margin concave, squamous portion very narrow, reaching short of middle of third antennular article; lateral tooth reaching to end of third article. Carpocerite slender, 8 times as long as broad, reaching well past end of antennular peduncle. Basicerite with strong tooth on inferolateral margin.

Large chela 2.4 times as long as broad with fingers occupying distal 0.25; dactylar articulation displaced laterally to proximal portion of chela. Promixal superior margin of palm continued as rounded ridge leading to palmar adhesive plaque, separated from distal superior ridge by flattened area broadly rounded with slight depression in middle. Superomedial ridge terminating distally in strong tooth at dactylar articulation, demarked proximally by transverse groove that extends a slight distance on to medial face; shoulder proximal to groove overhanging groove. Ridge to plaque demarked on inferior side by shallow rounded groove reaching to mid-palm. Ridge of lower margin of groove flattened and terminating in rather small but acute tooth flanking dactylar articulation. Inferior margin of palm bearing strong, rounded shoulder proximal to broad depression at level of superior transverse groove. Dactylus extremely compressed, curved with tip expanded especially on medial face; tip bearing patches of setae. Cutting edge of dactylus knife-like, somewhat curved and without trace of plunger. Cutting edge of pollex similar, but more concave and bearing promixally an angular tooth. Merus 1.5 times as long as broad superior margin projected in a rounded tooth bearing on its margins several short setae. Inferointernal margin bearing several small spines and an acute tooth distally. Ischium bearing one spine distally on inferior margin.

Small chela not sexually dimorphic, 4.5 times as long as broad, fingers and palm almost equal. Palm bearing distally an acute tooth on either side of articulation of dactylus. Dactylus displaced somewhat laterally. Superior and lateral surfaces rounded, glabrous. Medial face concave its entire length and with many setae. Tips cross when closed leaving no gape between fingers. Merus 3 times as as long as broad, inferointernal margin bearing several small spines and an acute tooth distally.

Articles of third maxilliped with ratio 10:4.4:6.5.

Carpal articles of second leg with ratio: 10:5.6:3.1:4.7:4.7.

Ischium of third leg with spine. Merus inermous, 8 timeas as long as broad. Carpus 0.6 as long as merus, superodistal margin projected as an obtuse tooth. Propodus 0.7 as long as merus, bearing on its inferior margin 9 pairs of spines and a pair distally; medial

surface, near superior margin of all three walking legs, bearing distally 2 or 3 setiferous bristles. Dactylus slender, 0.2 times as long as propodus, usually biunguiculate with inferior unguis small and acute; superior margin bearing tufts of setae.

Telson 2.6 times as long as posterior margin is broad. Inner spine of posterolateral pair over twice as long as outer, anterior pair of dorsal spines placed well anterior to middle.

DISCUSSION: Since Coutière's original description of *A. hailstonei* from the Maldives, De Man named two new varieties and Banner, raising De Man's names to subspecific rank, described a third (citations above). Banner also presented a table of 31 characteristics, some of which would serve to separate the subspecies and some to separate the species from related species. Miya (1974:118) chose from the earlier table those characteristics he believed could be used to separate the nominal subspecies, but he cautioned that "the validity of each subspecies might be questionable . . ."

In his descriptions De Man emphasized the proportions of the chelae and third legs, ratio of the carpal articles of the second legs, the armature of the merus and ischium of both chelipeds and the biunguiculation of the dactylus of the third legs. As the differences in the proportions were close and the number of intact specimens available to De Man was small, Miya chose to ignore these characteristics as reliable for use in separations; to this we agree. This left the number of spines on the merus and ischium of the chelipeds and the biunguiculation of the dactylus of the third leg.

None of the specimens in the present or in the Hawaiian collection had spines on the superior margin of the ischium or merus of either cheliped, but on the merus of the large cheliped there would be frequently one or more setae in positions comparable to the locations where the spines were found. All the Australian specimens carried 3-8 spines of variable size on the inferior margin of the meri of the large and small chelipeds. The inferior margin of the ischium of the large cheliped carried one to two spines, the small cheliped carried none. In as much as in other species such armature varies considerably, often with setae substituting for spines, and the number of spines or patches of setae also varies, we believe that this characteristic is unreliable.

Remaining then is the biungiuculation of the dactylus. Here, too, the inferior unguis, never large, varies in size. At our request Dr J. Forest of the Museum National d'Histoire Naturelle of Paris kindly re-examined the 4 specimens that Coutière had marked "Type" and found all had *"un minuscule ongle"* (Coutière had not shown or mentioned the secondary unguis). Dr Forest stated that in other specimens it was not possible to distinguish the secondary unguis from a strong swelling. In the Australian specimens the size of the secondary unguis was variable although always small, and in one 17 mm specimen the extra unguis was lacking. In view of the variability here, and in view of the variability in other species (*A. gracilis* Heller, p.60 below and *A. diadema* Dana, Banner, 1959:142, fig. 7), we believe that this criterion cannot be relied upon for the separation of the subspecies. Therefore we return all to the nominate species without distinctions.

It should be noted in passing that as these specimens are always dredged, each person working upon the species has reported that many, if not most, of the specimens available were in only fragmentary condition. Possibly the lack of sufficient intact specimens has prevented earlier workers and ourselves from discovering the extent of variation within the species.

BIOLOGICAL NOTES: This species is a deep water form and has been collected from 25 metres to 536 metres. The colour is unknown. Our specimens ranged in size up to 30 mm.

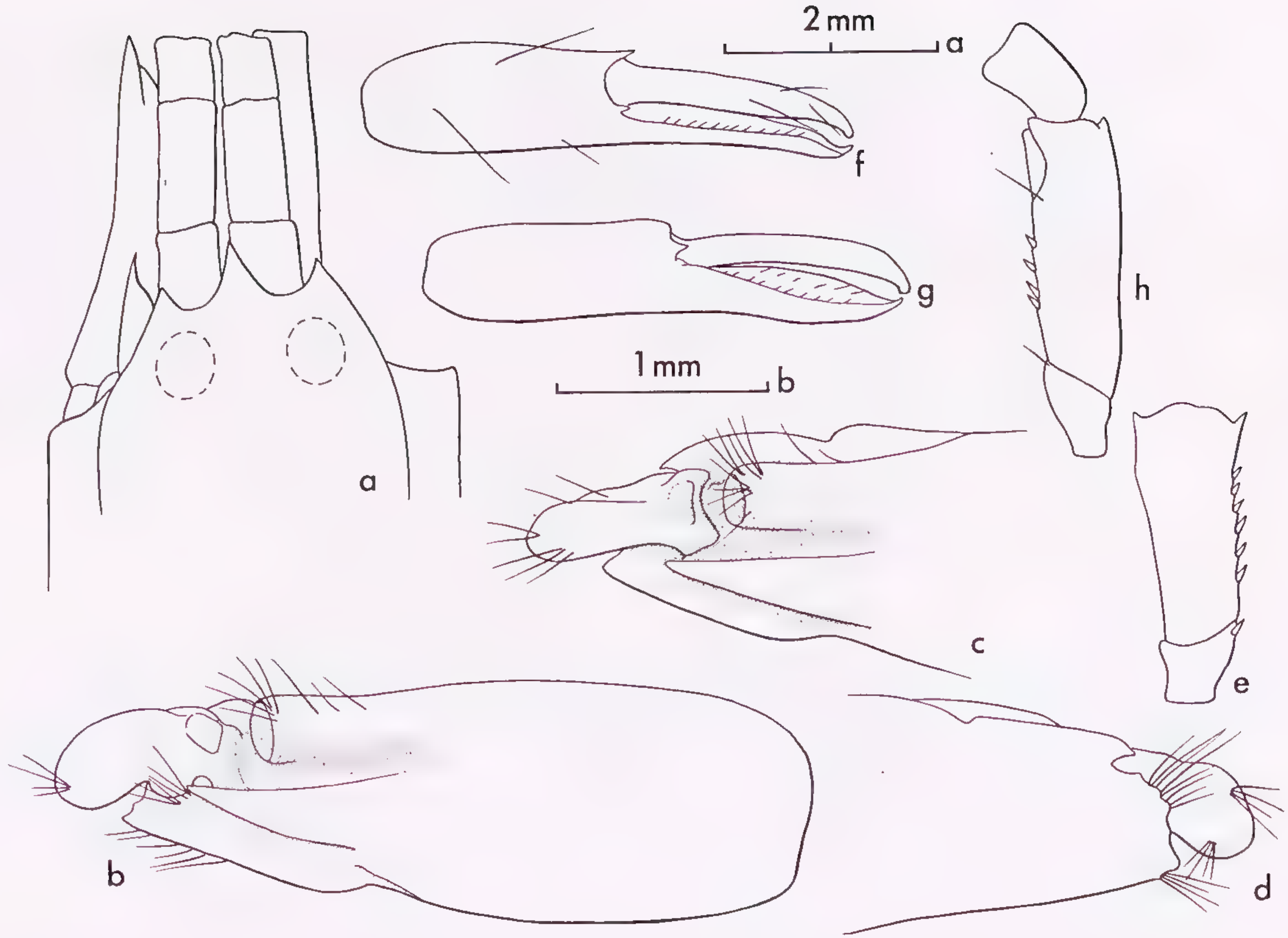

Fig. 7 *(?) Alpheus staphylinus* Coutière
14 mm specimen from AM 305. **a.** Anterior region, dorsal view; **b, c, d.** large chela, lateral face; distal region of superolateral face; distal region, inferior face; **e.** merus, large cheliped, medial face; **f, g.** small chela, superolateral and lateral face; **h.** merus, small cheliped, medial face. b, c, d, e, f, g, h scale a; a scale b.

AUSTRALIAN DISTRIBUTION: In Western Australia we have specimens from Cape Naturaliste to Bluff Pt.; in eastern Australia from off Cooktown Qld. to Cape Green N.S.W. We also have one specimen from Victoria.

GENERAL DISTRIBUTION: This species has been reported, either as the nominate form or its subspecies, from the Maldives, Amirantei, Seychelles, Indonesia, Japan and Hawaii.

(?)**Alpheus staphylinus** Coutière

Fig. 7

Alpheus staphylinus Coutière, 1908a:204; 1921:418, pl. 62, fig. 13.

Alpheus crockeri Miya, 1974, pl. 21. (*Nec* Armstrong, 1941.)

SPECIMEN EXAMINED: 1 specimen from AM 305 (AM P. 28114).

DIAGNOSIS: Rostrum triangular, a little longer than broad at base, reaching to last quarter of visible part of first antennular article. Anterior carapace dorsally rounded, without trace of orbitorostral grooves, orbital teeth half as long as rostrum.

Second antennular article 1.5 times as long as visible part of first and nearly twice as long as broad, third article 0.5 as long as second. Stylocerite reaching as far forwards as rostrum. Lateral margin of scaphocerite almost straight, lateral tooth strong, reaching to end of antennular peduncle, squamous portion reaching only to last quarter of third antennular article. Carpocerite a little longer than antennular peduncle. Lateral tooth of basicerite strong.

Large chela three times as long as broad with dactylus less than 0.3 as long as entire chela. Crest leading to superolaterally placed adhesive plaque heavy and rounded, arising from proximal portion of superior margin of palm and curving laterally to plaque. Superomedial crest separated from plaque crest by shallow flattened area and terminating in strong tooth at medial margin of dactylar articulation; crest interrupted proximally and re-arising as low, short crest, rounded in profile. Heavy crest on lateral face proximally flattened and demarked from plaque crest by deep groove; terminating in acute tooth with rounded tip lying on lateral side of dactylar articulation; inferior side of crest demarked by deep flattened area. Rounded concavity on inferior margin of palm somewhat proximal to fingers. Dactylus heavy, somewhat compressed, with rounded tip closing across end of pollex; plunger developed as a conical outstanding tooth with rounded apex, socket round and complete. Merus 2.5 times as long as broad, superior margin terminates distally in a rounded tooth, inferointernal margin bearing several small spines and terminating distally in an acute tooth.

Small chela 5.4 times as long as broad, palm and fingers equal. Palm without sculpturing and terminated both medially and laterally proximal to dactylus in an acute tooth. Opposing margins of fingers bearing a row of short stiff setae. Merus similar to that of large chela.

DISCUSSION: This sole specimen is fragmentary: the body and the appendages appear as if they had been soaked in a chemical (such as a household bleach or sodium hydroxide) that ate away most of the flesh and softened the exoskeleton. Most of the legs were already gone and the soft body was badly distorted when we first examined the specimen. In the process of examination the small chela was lost and the dactyl was broken off the large chela.

From the parts that are intact, we can see no differences between this specimen and

the species Coutière described as *A. staphylinus* from the Chagos Archipelago, the type of which we have examined at the Muséum National d' Histoire Naturelle of Paris. The orbital hoods and the relationship of the antennular and antennal peduncles are the same; both the large and small chelae are similar, but the interruption of the ridge leading to the medial articular tooth of the large chela which we show in fig. 7c is not shown in Coutière's figure 12a — that is merely because of rotation for it appears in the holotype. This specimen is also related to *A. crockeri* (Armstrong) and *A. astrinx* (described above), but can be separated from them by lack of modification of the plunger of the dactylus of the large chela; to *A. albatrossae* (Banner), but from it this species differs by having a relatively heavier and second antennular article; and to *A. oahuensis* (Banner), but that species differs by having the fingers of the small chela straight and heavy, not curved and simple.

Dr Miya reported some specimens from the Ryukyus as *A. crockeri* (Armstrong) *(loc. cit.)*. From his description and figure we suspected that the specimens might be *A. staphylinus*. We sent specimens of *A. staphylinus* from our Philippine collections to him and he compared them to his specimens from the Ryukyus and confirmed our tentative diagnosis; he has requested that we indicate the correction of his identification in this paper (personal communication).

AUSTRALIAN DISTRIBUTION: The sole specimen was collected from Murray Island, Torres Straits, in 1907.

GENERAL DISTRIBUTION: This species is known only from the Chagos Archipelago in the central Indian Ocean; it may also occur in Japan. We have specimens in our collections from the Philippines.

Alpheus deuteropus Hilgendorf

Fig. 8

Alpheus deuteropus Hilgendorf, 1878:834, pl. 4, figs. 8-10; Coutière, 1899:215, figs. 254, 255; Banner and Banner, 1966b:80, fig. 26; Tiwari, 1963:281, fig. 6.

Crangon deuteropus Banner, 1953:70, fig. 22.

Previous Australian records: O'Loughlin, 1969:36. Houtman Abrolhos, W.A.

SPECIMENS EXAMINED: 1 specimen from AC C-54; 1, AM 467 (AM P. 27410); 3, BAU 15; 3, BAU 17; 5, BAU 30; 2, BAU 31; 7, BAU 47; 1, BAU 55.

DIAGNOSIS: Rostrum acute, curved abruptly upward toward tip, tip reaching to middle of visible portion of first antennular article; rostral carina pronounced, rounded dorsally, and continuing to base of eyes. Orbital hoods inflated, with acute teeth about as long as rostrum. Medial margins of orbital hoods expanded and shelflike. Orbitorostral grooves moderately deep.

Second article of antennular peduncle slender, three times as long as broad, 1.5 times as long as visible portion of first and about twice as long as third article. Antennular peduncles hirsute. Lateral spine of stylocerite reaching to distal third of first antennular article. Outer margin of scaphocerite markedly concave, lateral tooth strong, reaching to end of antennular peduncle, squamous portion narrow, reaching only to end of second antennular article. Carpocerite as long as antennular peduncle. Basicerite bearing strong lateral tooth and adjacent shorter acute tooth.

Large and small chelae so densely hirsute on inner faces and superior margins of outer faces that their form is obscured; hirsute surfaces heavily papillose. Large chela

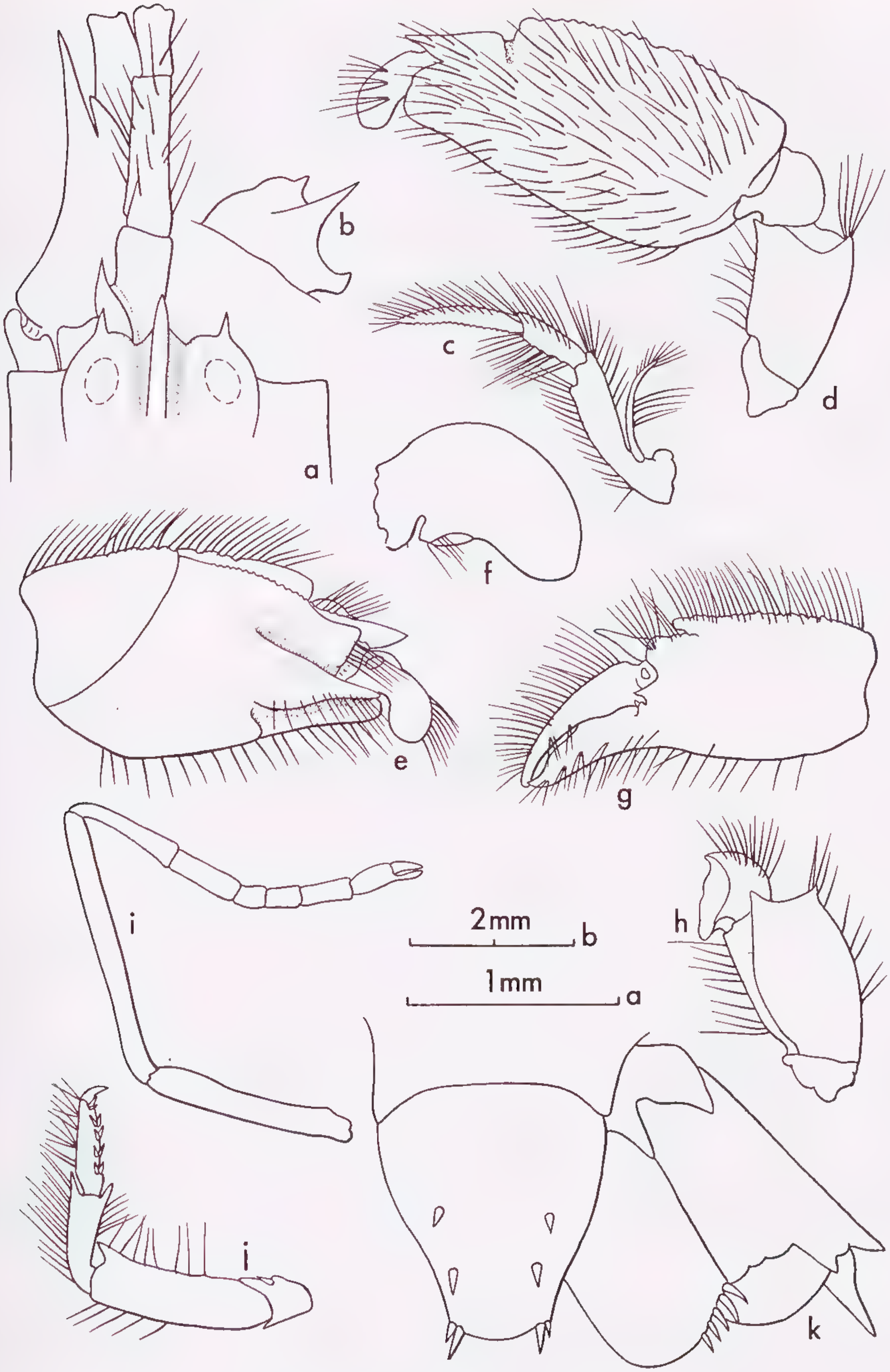

Fig. 8 *Alpheus deuteropus* Hilgendorf
25 mm male from BAU 15. **a.** Anterior region, dorsal view; **b.** basicerite; **c.** third maxilliped; **d.** large cheliped, medial face (dense layer of hairs not fully indicated); **e, f.** large chela and detail of dactylus, lateral face; **g, h.** small chela and merus, lateral face; **i.** second leg; **j.** third leg; **k.** telson and uropods. c, d, e, g, h, i, j scale a; a, b, f, k scale b.

strongly compressed, ovate in shape and about twice as long as high. Fingers approximately 0.2 as long as entire chela. Superior longitudinal crest rounded and bounded on either side by grooves; groove on lateral face extending to distal third of palm. Superior groove reaching to *linea impressa* with papillose superior margin of serrulate appearance. Superior margin interrupted by a deep transverse groove proximal to dactylar articulation. Dactylar articulation flanked by two heavy and acute teeth; superior being a continuation of superior margin, lateral arising below lateral groove; both reaching almost to end of shortened pollex. Inferior margin of chela rounded, much less hirsute than superior margin and bearing small shoulder opposite transverse groove. Tip of pollex truncate; cavity for plunger with "slot" in distal margin. Dactylus rotated somewhat laterally, with bulbous tip overhanging pollex; plunger short. Merus 1.5 times as long as broad, inferointernal margin projecting as slight acute tooth, superodistal margin forming a triangular projection; inferoexternal margins not projected.

Small chela 0.8 as long as large chela, ovate, fingers over 0.5 as long as palm. Dactylar articulation flanked by acute teeth, with medial prominent and lateral tooth small. Superior margin of palm bearing a transverse groove near dactylar articulation with proximal margin overhanging groove. Merus similar to that of large chela.

Third maxilliped densely hirsute. Ratio of articles: 10:4:8. Last article 6.6 times as long as broad, tapering distally.

Ratio of carpal articles of second legs: 10:6:2:2:4.

Ischium of third leg with spine. Merus 3.5 times as long as broad, with strong acute tooth distally and numerous hairs on superior and inferior margins. Carpus 0.5 as long as merus, both margins terminating in strong acute teeth. Propodus as long as carpus, bearing on inferior margin four pairs of small spines and a pair distally. Dactylus simple, curved.

Telson stout, anterior margin 2.2 times as wide as posterior margin. Lateral margins anteriorly convex, posteriorly concave. Anterior pair of dorsal spines at 0.5 of length. Distolateral margins of inner uropods bearing five strong spines.

DISCUSSION: Our specimens showed the same variation in characters as those discussed by Banner (1953:72) for 50 specimens from Hawaii. 1. The rostrum varied from slightly shorter to slightly longer than the orbital teeth. 2. The frontal margin of the carapace between the orbital teeth varied from almost straight to definitely arcuate. 3. The length of the stylocerite and relative lengths of scaphocerite, carpocerite and antennular peduncle varied. Usually the scaphocerite reached to somewhat past the middle of the third antennular article. 4. The second carpal article of the second legs varied from 0.55 to 0.85 times the length of the first article, usually being about 0.6-0.7 its length. The distal articles appeared to bear a more fixed relationship to the length of the second article than to the length of the first article. 5. The number of spines on the propodus of the third legs varied from four to seven pairs.

BIOLOGICAL NOTES: This species characteristically is found in fissures in massive heads of living coral. The following forms have been reported as hosts: *Astreopora myriophthalma* (Lamarck), *Porites lobata* Dana (B&B, 1964:88); *Porites spp., Acropora sp.* (B&B, 1966b:82); *Porites evermanni* Verrill, *Montipora verrucosa* (Lamarck), and *Pavona varians* Verrill (Vaughan, 1973:37 *et seq.*). It may continue to live in fissures persisting in heads after the coral has died and it has been found in dead bases of living coral heads. The species has been found from the low intertidal to depths of 35 m (Vaughan, *op. cit.*) but this was the limit of depth of his observations.

Vaughan *(op. cit.)* made an extensive study of *A. deuteropus*, its fissures, distribution and behaviour in Hawaii. He found that the fissures inhabited were from 0.3-0.9 cm wide and up to 25 cm long and that the longer fissures had the greater depths (*circa* 3 cm). Off the deeper parts of the U-shaped crevice were the burrows, rounded *cul-de-sacs* reaching deeper into the head and exactly fitting the shrimp that would retire there when disturbed, lying with its hairy chela effectively blocking the entrance. Vaughan found that 85 percent of the fissures he studied contained a cohabiting pair, each with its separate burrow; a few crevices less than 5 cm long had only one inhabitant and one burrow; in two cases he found in longer fissures two berried females with a male and in one other longer fissure he found two pairs living.

While Vaughan could not prove that the shrimp actually excavated the crevice-burrow unit, he could show that the fissure was not pre-existing in the growth form of the coral, that the groove was not made by any other known biological agent, and that it might be possible for the shrimp to inhibit the growth of coral and possibly excavate the coral with its large chela. He made sections through the coral head at the site of the groove and was able to count up to five annual growth rings to the sides of the groove; whether that meant that the shrimp had been in position for five years or whether it had actively burrowed through five years growth his studies did not show.

He found the rim of the groove to bear a band of small hydroids of various families embedded in a mass of filamentous alga dominated by the red alga, *Spermothamnion* that extended 2 cm from the lip. He speculated that the hydroids might with their nematocysts protect the inhabitants of the groove and might also eat the shrimp larvae when released. He was able to show that when the shrimp were removed from their dwellings and given fragments of the algal mat under laboratory conditions they would graze on the mat. He found the same algae in the gut contents of the shrimp freshly removed from their burrows, so the shrimp use the mat as a standing food crop. (All information from Vaughan summarised with his permission.)

It is noteworthy that when we were collecting in Indonesian waters in 1975 we found many massive heads of coral with grooves that appeared to be superficially similar to those made by *A. deuteropus*, but in almost all cases they were inhabited by *A. acutofemoratus* Dana (full collections not yet studied and will be reported in a future paper).

We have no colour observations on the Australian specimens, but in Hawaii the species has pink eyes, surrounded by a circlet of broken red lines and the body and appendages are largely transparent with a sprinkling of small red chromatophores; the gut shows through the carapace as brown, and the inner face and the tips of the fingers of the chelae are brownish. The embryos in maturing eggs are brown with black eyes.

The specimens ranged from 8 to 30 mm in length.

Australian distribution: One specimen was found in the Houtman Abrolhos in Western Australia, the remainder were found from off Port Douglas, Qld. to as far south as Heron Island in the Capricorn Group.

General distribution: South and East Africa, Maldive Archipelago; Thailand, Vietnam; Japan, Marianas; Marshall Islands; Samoa; Line Islands and Hawaii.

Alpheus collumianus Stimpson

Fig. 9

Alpheus collumianus Stimpson, 1861:30; Banner, 1953:67, fig. 21.

Alpheus collumianus probabilis Banner, 1956:338, fig. 10.

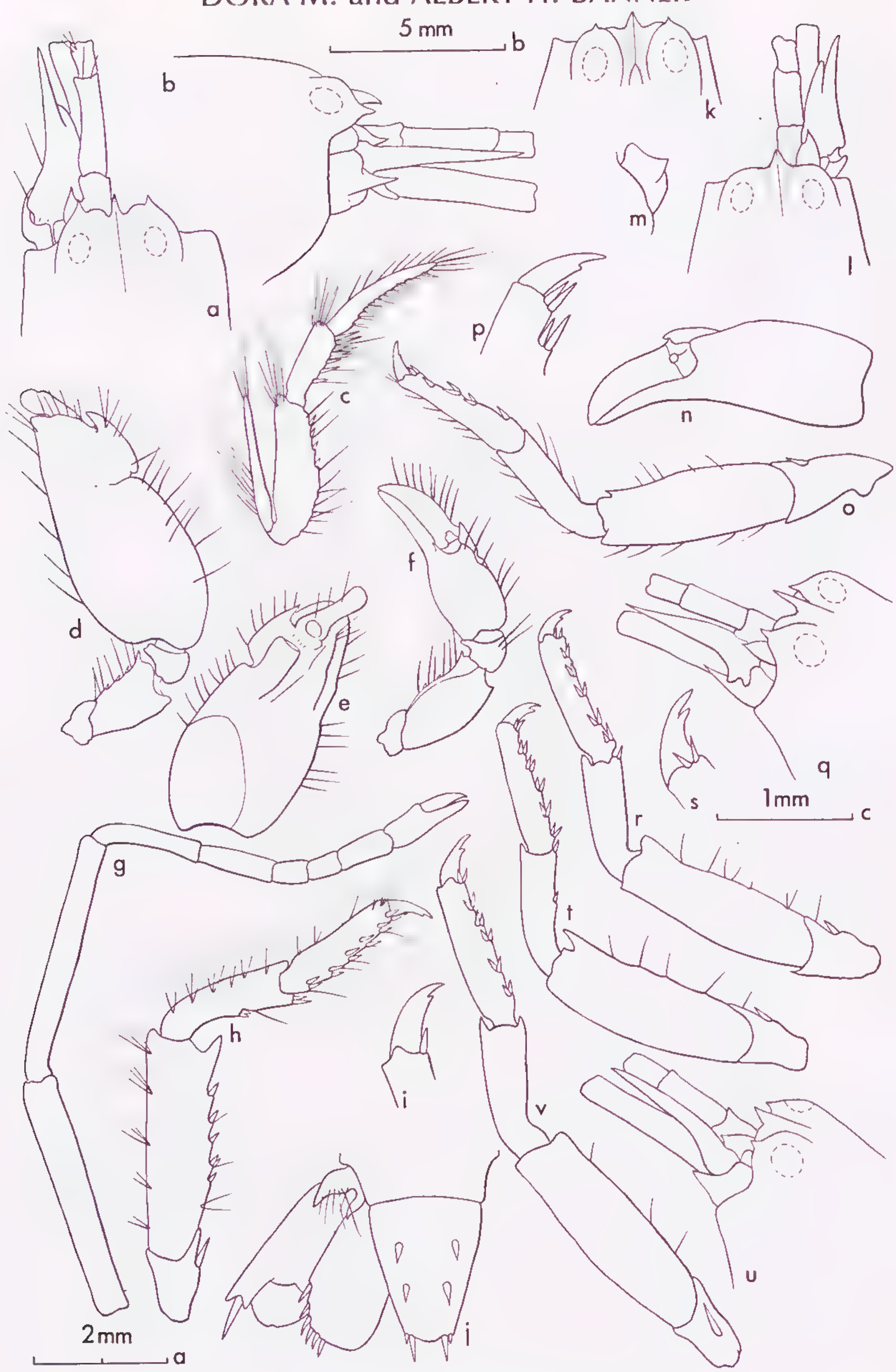

Fig. 9 *Alpheus collumianus* Stimpson
18 mm male from BAU 21. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d.** large cheliped, medial face; **e.** large chela, superolateral face; **f.** small cheliped, lateral face; **g.** second leg; **h, i.** third leg and enlarged dactylus; **j.** telson and uropods. Cohabiting pair from BAU 21; **k.** Anterior region of 15 mm female; **l.** anterior region of 15 mm male; **m.** basicerite of male; **n.** small chela of male, medial face; **o, p.** third leg and enlarged dactylus of male. 18 mm female from BAU 32; **q.** Anterior region, superolateral view; **r, s.** third leg and enlarged dactylus. 15 mm male from BAU 32; **t.** Third leg. 18 mm female from BAU 47. **u.** Anterior region, lateral view; **v.** third leg. a, b, c, g, h, j, k, l, m scale a; d, e, f, scale b; i, n, o, p, q, r, s, t, u, v scale c.

Alpheus collumianus medius Banner, 1956:340, fig. 11.

Alpheus collumianus inermis Banner, 1956:342, fig. 12.

Alpheus malhaensis Coutière, 1908a:205; 1921:419,pl. 62, fig. 14.

Previous Australian record: Coutière, 1900:414. Murray Is., Torres Straits.

SPECIMENS EXAMINED: 1 specimen each from AC 18, 29, 35, 57, 68, 74; 1, AC C-59; 4, AM 74 (AM P. 27470); 2, AM 98 (AM P. 27781); 10, AM 109 (AM P. 27508); 3, AM 305 (AM P. 27776); 1, BAU 11; 2, BAU 15; 2, BAU 18; 5, BAU 21; 5, BAU 29; 4, BAU 30; 3, BAU 31; 5, BAU 32; 12, BAU 33; 4, BAU 47; 2, BAU 48; 1, BAU 55: 2, 75 LIZ-7 (AM P. 27903); 1, 75 LIZ-C (AM P. 27904); 1, 75 LIZ-H (AM P. 27905); 2, 75 LIZ-I (AM P. 27906); 2, 75 LIZ-Q (AM P. 27907); 2, 75 LIZ-R (AM P. 28144); 3, 75 LIZ-T (AM P. 28143); 1, 75 LIZ-U (AM P. 27908); 2, 75 LIZ-V (AM P. 27909).

DIAGNOSIS: Rostrum acute, short, reaching to near middle of visible part of first antennular article, a little longer than wide at base. Rostral carina strong, narrowly rounded, extending posteriorly to behind eyes. Orbital hoods inflated, rounded. Orbital margin varying from lacking teeth to having teeth almost as long as rostrum. Margin of carapace of specimens without orbital teeth tapering gradually into rostrum; those specimens with orbital teeth have area between teeth and rostral base flattened with margin convex and separated from base of rostrum by rounded notch. Orbitorostral grooves deep but rounded, extending to posterior portion of orbital hoods.

Second antennular article 2.7 times longer than third and usually 2 or more times as long as visible part of first, and 2-3.5 times as long as broad. Stylocerite varying from having only a slight distal tooth to having a well-developed tooth reaching almost to end of first antennular article. Scaphocerite with strong lateral tooth reaching to end of antennular article, squamous portion narrow, reduced, much shorter than lateral tooth and reaching near end of second antennular article. Carpocerite reaching to or beyond end of antennular peduncle. Tooth on basicerite varying from a strong tooth that reaches to end of first antennular article to being a rounded to slighlty acute angle (figs. 9b, m, u).

First and third article of third maxilliped nearly equal in length, second article 0.6 as long as first. Inferior margins of both the first and second articles bearing a few short spines as well as fine setae.

Large chela heavy, compressed, nearly 1.3 times as long as broad. Palm marked distally by three crests, a strong superior crest terminating distally in acute tooth flanking superior side of dactylar articulation, a rounded crest terminating in adhesive plaque, a lateral flattened ridge terminating in strong lateral tooth at dactylar articulation. Superior crest arising proximally from narrow transverse saddle that reaches about 0.4 width of medial face. Plaque crest merging with superior margin of palm and demarked from superior and lateral crests by deep but rounded grooves. Lateral crest with inferior groove shallow. Inferior shoulder slight and rounded. Dactylus truncate, twisted laterally, and tip slightly overhanging end of pollex. Merus 1.5 times as long as broad; inferior margin bearing 3 short spines and terminating distally in a strong acute tooth.

Small chela about 3.0 times as long as broad with fingers and palm very nearly equal. Superior margin bearing a slight transverse groove at about middle of palm. Superior margin proximal to groove flattened and bordered on medial side by a slight shoulder. Superior margin distal to transverse groove terminating in strong

acute tooth at articulation of dactylus, similar to that of large chela. Palm also bearing acute tooth lateral to dactylar articulation. Medial face of chela moderately hirsute, lateral face glabrous. Merus 2.1 times as long as broad. Inferointernal margin bearing fine setae and a few small spines and terminating distally in a small acute tooth. Small cheliped of female similar to that of male but more slender.

Carpal articles of second leg with ratio: 10:7:3:3:5.

Ischium of third leg with spine. Merus 3.2-3.7 times as long as broad. Inferointernal margin bearing at times 4-5 strong spines and at times bearing no spines but only setae; distally varying from heavy acute tooth to rounded (see figs. 9h, o, r, t, v). Carpus 0.5 as long as merus, inferior margin may be smooth or may bear one to several spines, distal margins usually projected or bearing one or 2 spines. Propodus 0.6 as long as merus, bearing on inferior margin 5 pairs of spines and a pair distally. Dactylus 0.3 as long as propodus, biunguiculate with inferior unguis represented variously from a slight angle to a strong unguis 0.25 as long as superior unguis.

Telson 3.0 times as long as broad at posterior end. Distal portion of inner uropod beset with spines.

DISCUSSION: In the collections from the Marianas reported by the junior author in 1956 there seemed to be three forms of this species represented, differing chiefly in the development of the orbital teeth, orbitorostral front, the tooth of the stylocerite, the tooth of the basicerite, in the armature of the merus and carpus of the third legs and finally in the secondary unguis of the dactylus. These were described tentatively as separate subspecies, *A. c. probabilis* (name selected as the subspecies most likely to be similar to Stimpson's lost holotype) being consisently with heavy and numerous spines and teeth; *A. c. inermis* being almost devoid of this armature, and *A. c. medius* being somewhat intermediate between the two. In the 28 specimens then reported these characteristics seemed to sort themselves out with distinct breaks between the variability of one subspecies and the others. Although the inadequate field notes available could not substantiate the point, it was suggested that perhaps the three forms were ecologically isolated.

In one subsequent publication we reported the two subspecies present in a single collection, probably a cohabiting pair (from the Societies, B&B, 1967:264). This threw some doubt on the validity of the subspecific separation. However, in 1968 (p. 279) we reviewed 93 separate collections of the species then available to us and found "only 11 collections had the 2 subspecies represented, and none had all three."

In the present Australian collection each of the three morphological distinctions occurred, but often with "independent assortment", so that while the sets of characteristics usually went together as originally described, some were found in which these characteristics were mixed, for example, without the meral spines of the third legs (characteristic of *A. c. inermis*), but with the orbital teeth (characteristic of *A. c. probabilis*). They were not found to be ecologically separated as originally presumed, for example, in BAU 33, in one collection of 12 specimens from coral heads in one narrow zone all three subspecies occurred. Finally we discovered that the shrimp themselves do not recognize our distinctions, for as in the Society Islands, we found *A. c. inermis* and *A. c. medius* to make up a cohabiting pair (BAU 21). We found a similar confusion of characteristics in 58 specimens we collected from the southern Philippines. We regretfully conclude that if nature itself does not recognize our fine distinctions, perhaps we too should give up the subspecies

separations in this species.

However, it is still interesting to note that apparent geographical or ecological separation still appears. Thus, all of the 7 specimens from the Houtman Abrolhos lacked spines and terminal tooth on the merus of the third leg.

We have examined Coutière's holotype for *A. malhaensis* from Saya de Malha at the Muséum National d'Histoire Naturelle of Paris and find it no different than the form previously recognized as *A. c. medius*. Coutière had figured the dactylus of the third leg as simple (fig. 14c), but upon close examination was found to carry a small secondary unguis. We place this species in synonymy.

BIOLOGIAL NOTES: This species is common on reef flats; it has also been dredged as deep as 24-41 fathoms (Banner, 1953:70). Those Australian specimens for which we have collection records all came from dead coral heads in water up to 10 ft deep. Two cohabiting pairs from Arlington Reef (BAU 21, the mismatched pair cited above, the other of the form of *A. c. probabilis*) were noted to be bright red in life. This colour was also reported in a pair from the Societies *(loc. cit.)*. However, specimens collected from the Houtman Abrolhos (AC 57, 68, 74) were reported as being "yellow-brown with darker brown spots". One specimen from BAU 33 appeared to be living commensally with a brittle star *Ophiothrix (Placophiothrix) sp.* (identified by Dr Dennis Devaney of the Bishop Museum, Honolulu). Our largest specimen was 20 mm long.

AUSTRALIAN DISTRIBUTION: We have specimens from western Australia from Houtman Abrolhos; in northern Australia from Murray Island in the Torres Straits and on the east coast from Lizard Island in northern Queensland south to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: This species has been collected from the Red Sea and Madagascar to Japan and across the central Pacific to Hawaii and the Societies.

SULCATUS GROUP
(=Macrochirus Group)

Often with orbital teeth; at times with rostral base flattened and demarked from orbitorostral grooves. Large chela usually with light to heavy longitudinal grooves, usually without transverse grooves, never markedly compressed; dactylus normal. Small chela never balaeniceps. Third legs with or without meral tooth; dactylus biunguiculate or simple.

Most species appear to occur in dead or living coral, but some are found under coral heads and the range of some extends beyond the range of coral. The name has been changed from Macrochirus Group to Sulcatus Group as *A. macrochirus* Richters has been found to be a synonym of *A. sulcatus* Kingsley.

Alpheus villosus (Olivier)
Fig. 10

Palaemon villosus Olivier, 1811:664.

Palaemon diversimanus Olivier, 1811:663.

Alpheus villosus Milne-Edwards, 1837:354. Coutière, 1898f:204; 1899; fig. 47, 48, 126, 148, 266, 319, 320, 383.

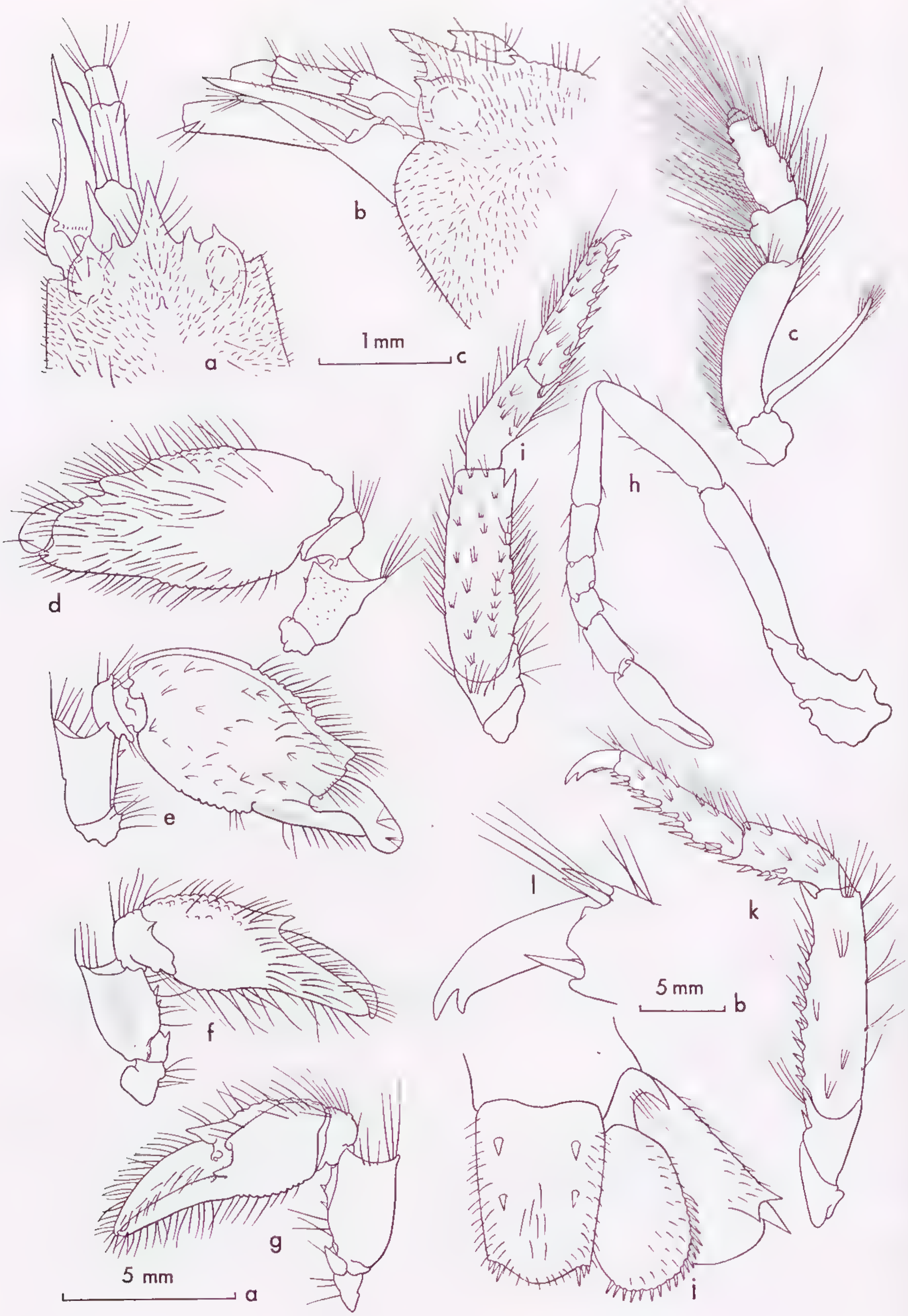

Fig. 10 *Alpheus villosus* (Olivier)
40 mm male from WM 296-65. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d, e.** large cheliped, medial and lateral face; **f, g.** small cheliped, medial and lateral face; **h.** second leg; **i.** third leg; **j.** telson and uropods. 38 mm male from WM 247-65. **k, l.** Third leg and enlarged dactylus. a, b, c, h, i, j, k scale a; d, e, f, g scale b; 1, scale c.

Paralpheus diversimanus Bate, 1888:568, pl. 102.

Previous Australian records:

Haswell, 1882b:187. Southern Australia.
Miers, 1884:290. N.E. Australia.
Ortmann, 1894:14. Thursday Is., Torres Straits.
Coutière, 1898f:206. (discussion of type)
Nobili, 1899:233. Beagle Bay, Dampier Land.
Sayce, 1902:155. Port Phillip, Victoria.
Balss, 1921:9. Cape Jaubert, W.A.
Hale, 1927a:46, fig. 37. S. Australia (as *Crangon villosus*).
Hale, 1927b:307. Baeres Pt., Kangaroo Is., S. Australia [as *C. villosus*].
Hale, 1941:265. S. Australia [as *C. villosus*].

SPECIMENS EXAMINED: 1 specimen from AC 40; 5, AM 15 (AM P. 27798); 1, AM 18 (AM P. 27785); 3, AM 21 (AM P. 27793); 2, AM 34 (AM P. 27822); 1, AM 122 (AM P. 28145); 1, AM 128 (AM P. 27823); 3, AM 139 (AM P. 27820); 2, AM 224 (AM P. 27819); 1, AM 248 (AM P. 27829); 2, AM 303 (AM P. 28146); 2, AM 308 (AM P. 27784); 4, AM 382 (AM P. 27834); 1, AM E. 4496; 4, AM E. 4497; 1, AM G. 614; 1, AM P. 2055; 1, AM P. 2344; 2, AM P. 2768; 6, AM P. 3014; 8, AM P. 3956; 1, AM P. 8702; 1, AM P. 9422; 1, AM P. 13583; 4, AM P. 14959; 5, AM P. 27884; 12, AM P. 27885; 1, BAU 28; 2, SM C-501; 2, SM C-502; 1, SM C-504; 4, SM C-505; 1, SM C-514; 1, SM C-1074; 1, TM G1461; 1, TM G1511; 1, TM G1528; 1, VM 1; 4, VM 10; 13, VM 11; 2, VM 17; 1, VM 18; 2, VM 22; 1, VM 30; 1, VM 33; 1, VM 25S; 2, VM 33S; 2, VM 41N; 1, WM 38-65; 3, WM 85-65; 1, WM 105-65; 1, WM 187-65; 2, WM 212-65; 2, WM 226-65; 2, WM 247-65; 1, WM 274-65; 1, WM 293-65; 6, WM 296-65; 1, WM 301-65; 1, WM 298-65; 1, WM 6052; 1, WM 8752; 1, WM 9982; 1, WM 10468; 1, WM 10570; 1, WM 108-60; 1, WM 11100/1; 1, WM 115-33.

DIAGNOSIS: Entire body hispid with short stiff setae interspersed with scattered long setae, all arising from small bosses. Rostrum acute, 1.8 times as long as broad at base, slanted upward and reaching end of first antennular article; carina sharp, carrying acute, forward-directed tooth at level of posterior margin of eyes, and continued posteriorly as sharp ridge to mid-carapace. Orbital hoods inflated, each with acute tooth overhanging anterior margin of hood. One small triangular tooth on orbitorostral margin between orbital hoods and base of rostrum. Eyes never brown to black, at times appearing chalky or ranging from a light yellow to a dark red in alcohol.

Second antennular article about 2 times as long as broad and 1.3 times length of first and almost twice length of third article; all articles with scattered long setae. Stylocerite with prominent lateral tooth reaching beyond end of first antennular article. Scaphocerite with lateral margin concave, lateral tooth reaching beyond end of antennular peduncle, almost to end of carpocerite; squamous portion narrow, reaching middle of third antennular article. Carpocerite reaching more than half length of third antennular article past that article. Basicerite with lateral tooth heavy, cylindrical and reaching to end of second antennular article; inferior to major tooth lies a minute but acute tooth (not seen from angle of fig. 10b).

Third maxilliped stout, third article 2.2 times as long as broad. Medial surface of all articles bearing long hairs with those of second and third articles long, thick and brushlike.

Large chela compressed, 2.2 times as long as broad with fingers occupying the distal 0.2. All surfaces of chela bearing small tubercles, lateral face with short bristles, but medial face with thickly set stiff setae that sweep forward. Medial face without grooves.

Superior face with obliquely directed longitudinal groove extending from carpal to dactylar articulation. Lateral margin of groove smooth, medial serrate. Lateral face with smooth broad groove arising mid palm and extending to dactylar articulation. Near inferolateral margin is a moderately deep longitudinal groove that extends from inferior shoulder nearly to distal portion of pollex. Dactylar articulation flanked by acute teeth on either margin. Tip of dactylus truncate, overhanging end of pollex. Inferior margin of ischium with three spines. Merus 2 times as long as broad, surface covered with bosses carrying hairs. Inferointernal margin bearing two or three spines, distally bearing a small acute tooth. Superior margin projected into a broad rounded tooth and bearing a tuft of setae.

Small chela not sexually dimorphic, 2.7 times as long as broad, fingers and palm nearly equal. Dactylar articulation flanked by teeth, with medial tooth longer and curved upward. Superior margin bearing groove directed obliquely toward lateral face similar to that of large chela. Merus similar to that of large chela.

Carpal articles of second leg with ratio: 10:5:2:2:5. Chela as long as last three articles.

Ischium of third leg armed with spine. Merus 2.7 times as long as broad, inferior margin bearing about seven patches of short stiff setae, or alternatively with definite spines, and terminating distally in a strong acute tooth. Superior margin terminates in a patch of moderately long stiff setae. Carpus 0.6 as long as merus, inferior margin bears two to three patches of setae or spines similar to those on merus and terminating in acute tooth; superior margin projected but rounded. Propodus a little longer than carpus, with inferior margin bearing six pairs of spines and a pair distally. Superior margin beset with a series of patches of long stiff setae with a spine distally. Dactylus biunguiculate, inferior unguis two-thirds as long as superior.

Telson 1.7 times as long as broad, anterior margin 1.3 times as wide as posterior. Anterior pair of dorsal spines placed anterior to middle. Lateral margin of inner uropod bearing a row of spines.

DISCUSSION: Olivier in 1811 described among other species collected by Perron (or Péron) two species that are now believed to be identical. One was named *Palaemon villosus* from the "mer des Indies" but bearing the label in the vial of "Port du Roi Georges", presumably King George Sound at Albany, W.A., and the other was named *P. diversimanus* from "Nouvelle Hollande". The specimens of "*P. diversimanus*" evidently have been lost, and the exact locality of collection cannot be ascertained as Péron accompanied-Nicolas Baudon, who in 1800-1804 explored and mapped the south and west coasts of Australia from near Sydney around to Melville Island. In his terse descriptions, Olivier did not contrast the characteristics or otherwise distinguish between the two named forms.

In 1837 Milne-Edwards re-described *A. villosus* and stated (p. 354) that *A. diversimanus "ne me parâit pas devoir être distingué spécifiquement de l'Alphée velu . . ."* But he did state that *A. diversimanus* had a little more abundant hairs which were a little stiffer. Others accepted this synonymy until Bate (1888) revived the specific name *diversimanus* and created it for a new genus, *Paralpheus;* his specimen came from off Cape York. In 1898f Coutière re-examined the specimens of Bate and decided that his *Paralpheus diversimanus* was actually *Alpheus villosus*. In his 1899 Thesis Coutière provided some excellent figures of the species (see above). Since that date the name has stood except for that interim when the name *Crangon* was substituted for *Alpheus*.

This species shows variation on a number of characteristics. In preservation and

possibly in life there is a variation noted above in the eye colour. The rostrum may reach considerably short of the end of the first antennular article to somewhat beyond; the carinal tooth at the level of the posterior margin of the eyes may vary from a slight protuberance to a large acute tooth.

The lengths relative to the antennular articles of the carpocerite itself and the large tooth of the basicerite both vary. The ratio of lengths of the first two carpal articles of the second legs ranges from 10:5 to 10:8. In Bate's figure (pl. 102, fig. v) he showed two spines on the distal portion of the outer uropod; two of our specimens were similarly armed, but all other specimens had but a single tooth. Other minor differences in proportions were seen.

However, the armature of the merus and carpus of the third legs can be used to separate the species into two distinct forms. One form, mostly from south temperate waters, carries tufts of setae on the inferior borders of these articles; the other, always from tropical waters, carries distinct spines in place of the setae (contrast figs. 10i and 10k). Between the two forms we have found no intermediates, such as thicker setae or finer spines approaching setae. This difference has not been noted by earlier workers. Coutière, in his figure of the third leg (1899; fig. 319) showed spines on the type specimens, but our examination of the same specimen (Olivier's, from Port du Roi Georges) showed these were not spines but setae. Bate's specimen of "*diversimanus*" (pl. 102, fig. 1) was shown to have spines as would be expected from its tropical location, but Coutière (1898f) in his re-examination of the specimen did not remark on the difference.

We were initially inclined to consider the form bearing the spinose articles as a distinct and geographically separated sub-species. The northern form did not extend beyond the Torres Straits (about 11°S) in the east nor beyond Exmouth Gulf (about 22°S) in the west, while the southern form did not reach further north than 37°S in the east nor 32°S in the west save for one specimen from Houtman Abrolhos (at about 28°43′S). However, after we had made the decision two additional specimens were received that upset this geographical separation: the specimen from SM C505, from "Northern Territory" noted above, and one specimen from the Sulu Archipelago, Philippines (WM 216-65), neither of which have the spines on the third legs characteristic of the other tropical specimens. We therefore are deferring the separation of the species into geographical or ecological sub-species until further studies are made.

Two other minor mistakes have appeared in the literature. Bate described the dactylus of the third leg as being "single pointed"; this was corrected by Coutière in his re-description. Coutière (1899, fig. 383) did not show the row of small spines on the margins of the inner uropod, but our re-examination of the holotype showed these were present and they were found on all other specimens we have examined.

BIOLOGICAL NOTES: This species has been reported to reach 67 mm in length. It has been dredged as deep as 24 fathoms and taken from corals collected intertidally. The specimens for which the habitat was noted in the collection data, were recorded from cryptic locations; the sole specimen we ourselves collected was from deep within a head of coral. It is probable that the lack of normal pigmentation of the eyes is associated with this dimly lit or lightless habitat.

The colour notes on the northern and southern forms show similar colouration. The specimen we collected from the Torres Straits region was lemon yellow with stellate red chromatophores, with red and white striped antennules and antennae and red eyes. The colour notes on a specimen supplied by the Fisheries and Wildlife Department of Victoria (VM 33S) from Western Port stated "All over pale light orange, spotted with red stellate

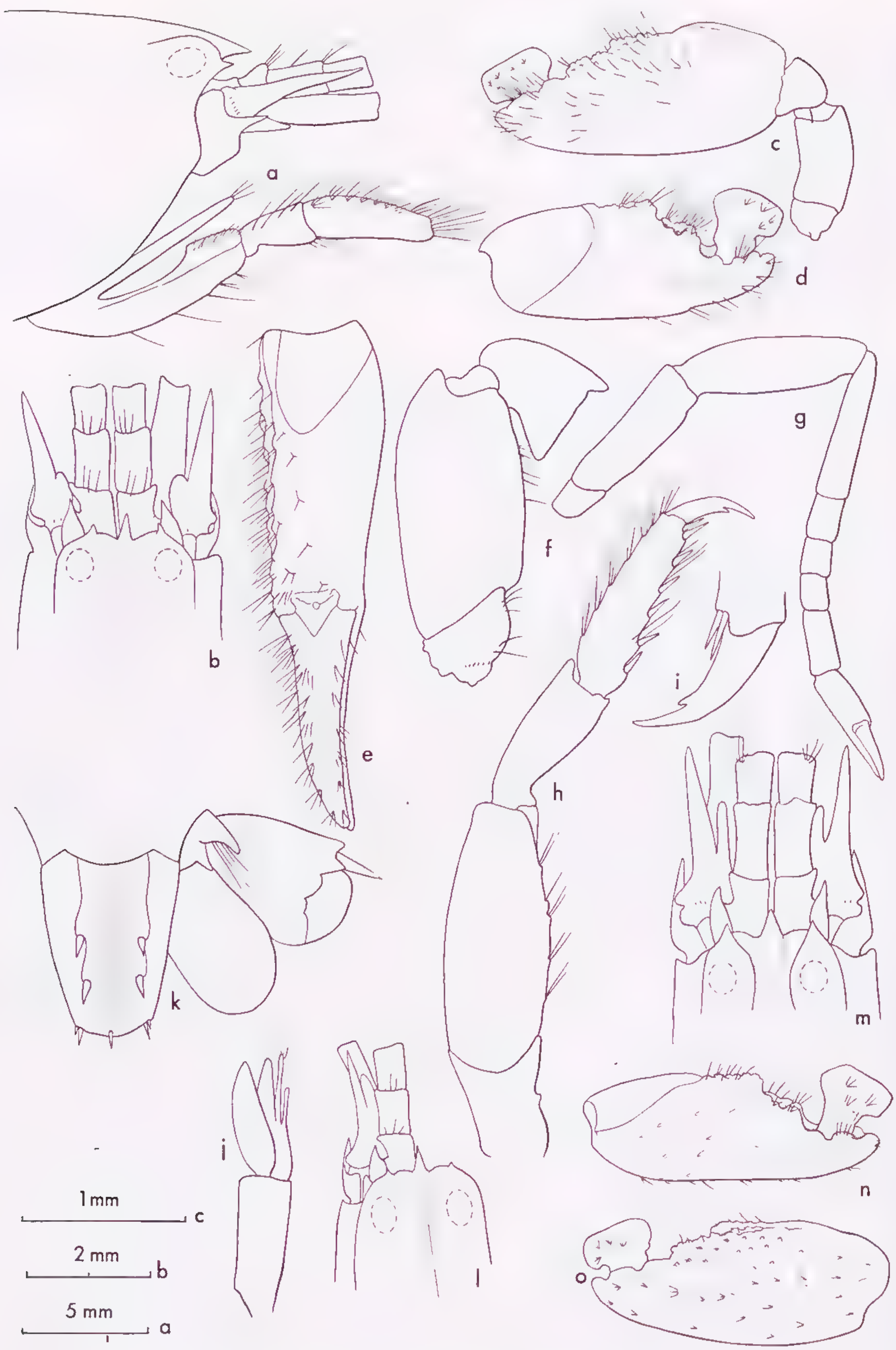

Fig. 11 *Alpheus architectus* De Man
24 mm female from US 123599. **a, b.** Anterior region lateral and dorsal view; **c.** large cheliped, medial face; **d.** large chela, lateral face; **e.** small chela, superior face; **f.** merus of small cheliped, medial face; **g.** second leg; **h, i.** third leg and dactylus enlarged; **j.** second pleopod, male; **k.** telson and uropods. 15 mm female from AM 185. **l.** Anterior region, dorsal veiw. 24 mm syntype of *Alpheus bullatus* Barnard. **m.** Anterior region, dorsal view; **n.** large chela, lateral face; **o.** large chela, medial face. c, d, n, o scale a; a, b, e, f, g, h, j, k, l, m scale b; i, scale c.

chromatophores. Medial face of large chela bright orange, eggs orange. Dorsal spines of telson and posterior lateral spines orange". Similar colours were reported by Hale (1927a:46) and for the specimen from Houtman Abrolhos (AC 40).

AUSTRALIAN DISTRIBUTION: "Southern form" from Twofold Bay, N.S.W., south and west to Perth, W.A. (with extensions noted above); "Northern form" from Exmouth Gulf east to Torres Straits.

GENERAL DISTRIBUTION: South Africa; Mascarene Islands; Sulu Sea, Philippines (reported above).

Alpheus architectus De Man

Fig. 11

Alpheus architectus De Man, 1897:726, fig. 60.

Alpheus bullatus Barnard, 1955:45, fig. 22.

SPECIMENS EXAMINED: 1 specimen from AM 185 (AM P. 28115); 3, US 123599.

DIAGNOSIS: Rostrum 2 times as long as wide at base, tip reaching past middle of visible part of first antennular article. Carina sharp and high to behind eyes then broadening and becoming rounded, finally constricting again and merging with carapace near middle. Orbital hoods bearing short acute teeth. Orbitorostral margin arcuate, set off from margins of rostrum by curved notch. Orbitorostral grooves moderate, rounded.

Second antennular article 1.5 times as long as broad and sub-equal in length to visible part of first and third articles; distal margins of first two articles bearing a few stiff setae. Stylocerite acute, not reaching end of first antennular articles. Scaphocerite with heavy lateral tooth reaching near end of antennular peduncles, squamous portion usually rudimentary, but if developed, narrow, not reaching further than middle of third antennular article.

Large chela moderately compressed with a hammer-shaped dactylus. Chela 2.4 times as long as broad with fingers occupying distal 0.2. Superior surface of chela developed as flattened shelf immediately behind dactylar articulation (to accommodate end of dactylus when flexed); proximal to this is a low rounded ridge extending to *linea impressa*. Superodistal portion of medial face carrying large bosses from which spring single and groups of stiff bristles; bosses giving way to small punctae on middle and lower portions of face. Lateral face almost glabrous, but with deep "V"-shaped groove originating near *linea impressa* half-way up on palm and continuing to slightly beyond dactylar articulation. Adhesive plaques large. Dactylus extending well beyond short pollex; pollex and sides of dactylus near tip bearing tufts of short stiff bristles.

Small chela 2.7 times as long as broad, 0.75 as long as large chela. Lateral face smooth with some pustules near superior surface. Superior surface developed as slight rounded shoulder running from *linea impressa* to dactylar articulation and carrying tufts of short setae set in depressions. Superomedial area bearing scattered pustules with patches of short bristles. Upper portion of lateral face bearing a few patches of short setae. Pollex carrying knife-like cutting edge on medial side, meeting low angular ridge on dactylus; tips curved and crossing. Merus 1.8 times as long as wide, distal margins without teeth.

Ratio of carpal articles of second leg: 10:8:3:3:6.

Third leg robust. Ischium without spine, merus inermous, 2.7 times as long as broad, bearing patches of setae on inferior margin. Carpus 0.6 as long as merus with upper and

lower distal angles extended as blunt teeth. Propodus 0.8 as long as merus, lower margin carrying five heavy spines and a pair distally. Dactylus biunguiculate, lower unguis one-sixth of upper, both ungui similarly curved.

Telson 2.2 times as long as wide at posterior margin. Dorsal spines carried on two high rounded longitudinal ridges with broad depression at midline and flat along edges. First pair of dorsal spines placed anterior to middle. At times posterior margin of telson with one or two spines near middle, in addition to usual posterolateral pairs.

DISCUSSION: In addition to the three specimens listed above, we have a large series from Madagascar that were concurrently studied. Our specimens are in agreement with the two specimens that De Man originally described from Atjeh. In the only Australian male the *appendix masculina* of the second pleopod was much longer than the *appendix interna* (fig. 11j) and as long as the endopodite; the male specimens from Madagascar were of similar development. In most species of the genus *Alpheus,* except some in the Crinitus Group, the *appendix masculina* is only a little longer than the *appendix interna* and not nearly as long as the endopodite; this condition was not remarked upon by De Man. In the genus *Metalpheus* and in the Atlantic genus *Thunor* the greater development of the *appendix masculina* is considered to be of generic importance.

Through the courtesy of Dr B. F. Kensley of the South African Museum we were able to examine a male syntype of *Alpheus bullatus* Barnard which we compared to the specimens from Australia and from Madagascar. We have figured the large chela and anterior region of the carapace of the syntype. The orbitorostral margins, figured by Barnard as concave, we found to be convexly arcuate. It had the long *appendix masculina* like the others in our study collection. We could find no major differences between this specimen and others in the collection, so we do not hesitate to place *A. bullatus* in synonymy to *A. architectus.*

BIOLOGICAL NOTES: These specimens were found intertidally under corals. The specimens from Madagascar were collected from eel grass beds. Moulton, who collected the specimens from Wistari Reef (US 123599), noted that they were "dark red in life, prominent white markings on large chela". The largest specimen was 32 mm in length.

AUSTRALIAN DISTRIBUTION: The specimens came from northern New South Wales and Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: De Man's specimens came from Atjeh; Barnard's from South Africa; we will report on the Madagascar specimens in a later paper; there are no other records.

Alpheus splendidus Coutière
Fig. 12

Alpheus splendidus Coutière, 1897a:235. De Man, 1924:41, fig. 14; 1929:23, pl. 3, fig. 8. Crosnier and Forest, 1965a:361, fig. 4 *(passim).*

Alpheus pomatoceros Banner and Banner, 1966b:93, fig. 32.

SPECIMENS EXAMINED: 1 specimen from BAU 32.

DIAGNOSIS: Rostrum acute, 2 times as long as broad at base, reaching to just past end of first antennular article. Rostrum with rounded carina that extends posteriorly to behind base of eyes. Orbitorostral grooves rounded, moderately deep. Anterior margins of orbital hoods evenly rounded and extended as flattened prominences, orbitorostral

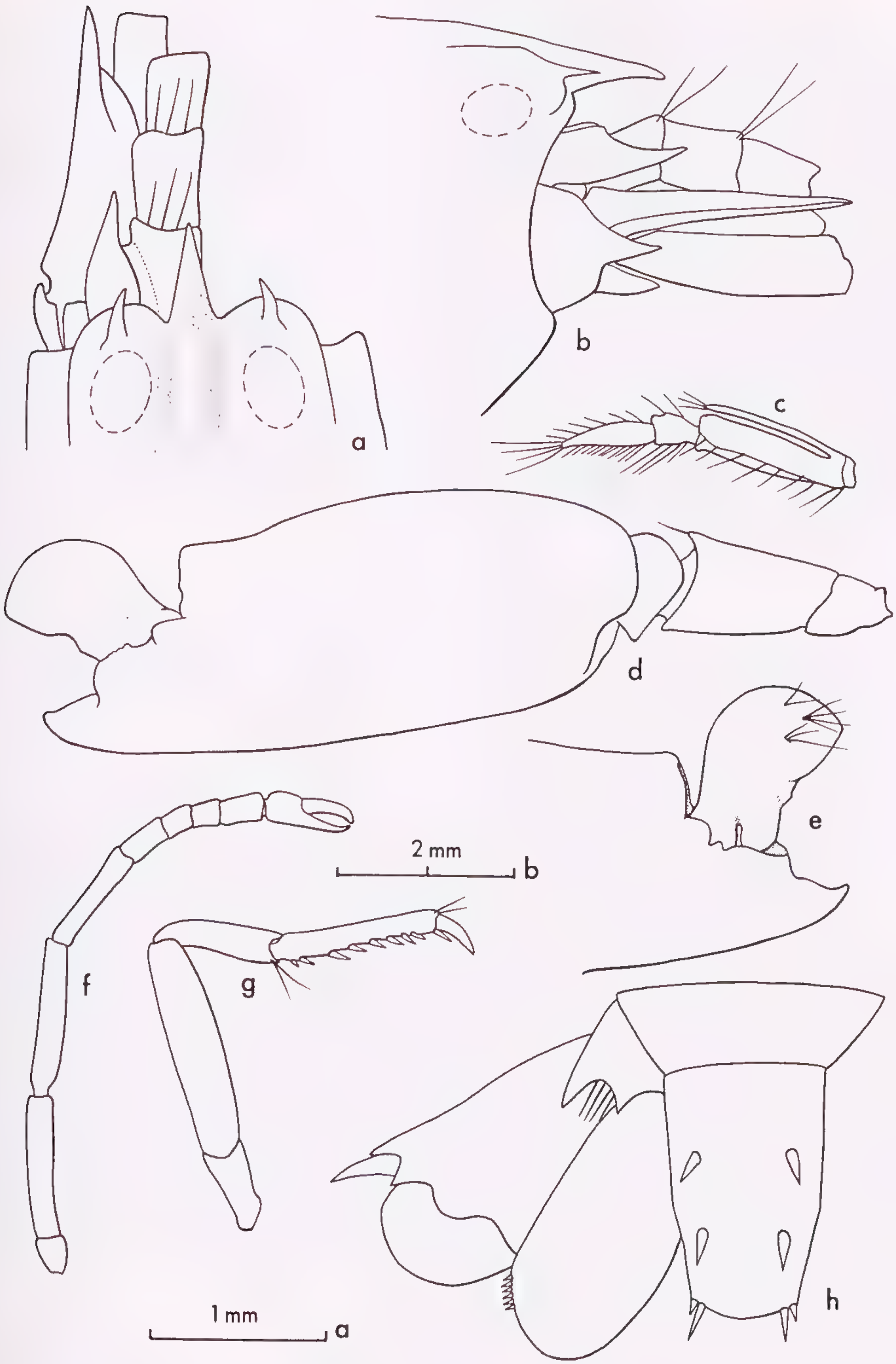

Fig. 12 *Alpheus splendidus* Coutière
14 mm specimen from BAU 32. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d, e.** large cheliped, medial face and distal region, lateral face; **f.** second leg; **g.** third leg; **h.** telson and uropods. a, b, c, h scale a; d, e, f, g scale b.

margin concave. Short acute orbital teeth arising from upper curvature of hoods, not from margins, and curved somewhat medially.

Visible portion of first antennular article a little longer than either of two following; second article 1.2 times as long as wide and as long as third. Stylocerite acute, reaching slightly past end of first article. Scaphocerite with lateral margin slightly concave, lateral tooth reaching almost length of third antennular article past that article, squamous portion reaching just past end of antennular peduncle. Carpocerite longer than squame. Spine of basicerite broad at base, tip reaching near end of rostrum.

Large chela moderately compressed, 2.7 times as long as broad with fingers occupying distal 0.27. Superior margin bearing a narrow, shallow longitudinal groove that extends from promixal third to near articulation of dactylus. Dactylus truncate at tip, plunger prominent. Merus 1.8 times as long as broad, inferointernal margin terminating in acute tooth, superior margin with strong rounded projection distally. Small chela not sexually dimorphic, 4.3 times as long as broad with fingers slightly longer than palm; tips of fingers hooked and crossing. Palm bearing medially at articulation of dactylus an acute tooth, no tooth on distolateral margin. Merus 1.4 times as long as broad. Inferodistal margin terminating in small acute tooth, superior margin in a prominent tooth and inferoexternal margin rounded.

Carpal articles of second leg with ratio: 10:4:3:3:4.

Ischium of third leg unarmed, merus 5 times as long as broad, unarmed. Carpus slender, 0.5 as long as merus with distal margins slightly projected. Propodus 0.7 as long as merus and bearing on its inferior margin 8 spines and a pair distally. Dactylus simple, 0.25 as long as propodus.

Telson 2.3 times as long as broad at posterior end. Inner spine of posterolateral pair 2 times as long as outer.

DISCUSSION: In 1966 we described from the Gulf of Thailand what we believed to be a new but closely related species to *A. splendidus* which we named *A. pomatoceros*. We separated the two species on the basis of the large chela; in as much as Coutière had given only a sketchy description of the chela and no figures, we used the redescription and figure of De Man (1929) of a specimen from the Malacca Straits. In 1965 Crosnier and Forest published a drawing of the anterior body region and the large chela of the holotype, the latter being quite different than that of De Man. Dr Forest of the Muséum National d'Histoire Naturelle of Paris agreed to compare the holotype with 2 specimens we had collected in the Philippines that were identical to our Australian specimen; he could find no important differences. We have also re-examined our specimens from Thailand and find that they belong to *A. splendidus* as now described. They have the slight longitudinal groove on the superior surface of the large chela, a characteristic found in *A. splendidus* which we had failed to note in the original description. On the basis of these comparisons, we are assured that the specimens from Australia, the Philippines and the Gulf of Thailand are all *A. splendidus* and we are placing *A. pomatoceros* into synonymy.

We have also had the opportunity to re-examine De Man's specimen from the Malacca Straits through the kindness of the Zoologisch Museum in Amsterdam. We found that its characteristics except for the chela were those of *A. splendidus*, but that the chela, loose in the jar, appeared to be that of *A. parvirostris* Dana. We are therefore presuming that De Man's record of the species from Indonesian waters is correct, but that his drawing of the chela was in error.

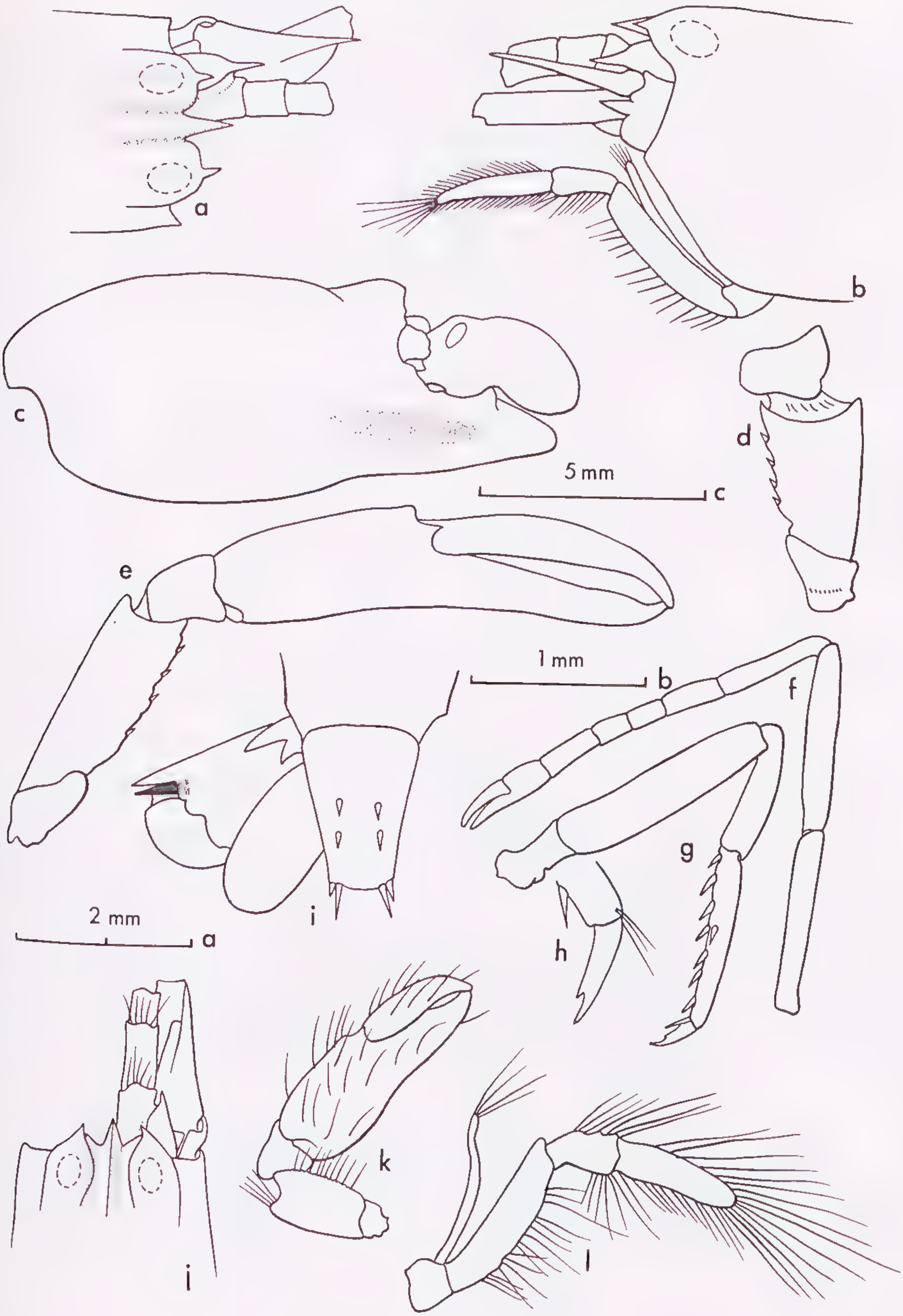

Fig. 13 *Alpheus gracilis* Heller
16 mm female from BAU 33. **a, b.** Anterior region, dorsal and lateral view; **c.** large chela, lateral face; **d.** Merus of large cheliped, medial face; **e.** small cheliped, medial face; **f.** second leg; **g, h.** third leg and enlarged dactylus; **i.** telson and uropods. 15 mm female from BAU 29. **j.** Anterior region, dorsal view; **k.** small cheliped, medial face; **l.** third maxilliped. a, b, c, d, e, f, g, i, j scale a; h, k scale b; l scale c.

BIOLOGICAL NOTES: This species has been collected only intertidally. Coutière's colour remarks in his original description are as follows: " . . . *une étroite bande jaune vif du rostre au telson, bordée de deux bandes brunes; le reste du corps rougeâtre, sauf deux étroites lignes blanches contiguës aux bandes brunes; pinces orange clair*". The Australian specimen is only 20 mm in length, but we have some specimens from Hong Kong that are 50 mm.

AUSTRALIAN DISTRIBUTION: Our one specimen came from Opal Reef on the Great Barrier Reef near Port Douglas.

GENERAL DISTRIBUTION: Red Sea, Seychelles, Indonesia, Malaysia, Thailand, Philippines and Hong Kong.

Alpheus gracilis Heller
Fig. 13

Alpheus gracilis Heller, 1861:271, pl. 3, fig. 19, 20. De Man, 1897: 733, fig. 60g, h *(passim in texto)*. Tiwari, 1963:283, fig. 7.

Alpheus gracilis Alluaudi Coutière, 1905a:882.

Alpheus gracilis luciparensis De Man, 1911:337, fig. 66.

Alpheus gracilis gracilis Banner and Banner, 1968:280.

Crangon gracilis simplex Banner, 1953:75, fig. 25.

Alpheus gracilis simplex Banner and Banner, 1966b:97, fig. 34; 1968:280.

? *Alpheus gracilis* Stebbing, 1919:123, pl. 20. Barnard, 1950:742.

SPECIMENS EXAMINED: 1 specimen from BAU 29; 1, BAU 33; 1, JG 6-73.

DIAGNOSIS: Rostrum acute, rounded dorsally, without carina; tip reaching past middle of visible part of first antennular article. Orbital hoods with narrow acute teeth well demarked from curvature of hoods; tips reaching past middle of rostrum. Orbitorostral margin deeply incised but rounded; orbitorostral grooves shallow and rounded. Antennular peduncles with second antennular article about 0.7 as long as visible part of first and only slightly longer than broad. Stylocerite large with lateral spine reaching to middle of second antennular article. Scaphocerite with strong lateral spine reaching beyond, and squamous portion subequal to, antennular peduncle. Carpocerite as long as lateral tooth of scaphocerite. Lateral tooth of basicerite prominent, as long as rostrum.

Large chela compressed, 2.5 times as long as broad, with fingers occupying distal 0.3. Superior margin bearing shallow rounded transverse depression proximal to dactylus; below this depression the inferior margin showing a slight constriction. Inferior third of lateral face bears shallow longitudinal depression that extends proximally from near middle of pollex to level of constriction on inferior margin. Dactylus not carinate, tip rounded; plunger of moderate development. Merus 1.5 times as long as broad, superodistal margin slightly projecting but rounded, inferointernal margin bearing 4 spines and a small acute tooth distally.

Small chela not sexually dimorphic, 4.6 times as long as broad; fingers a little longer than palm. Palm bearing tooth at dactylar articulation. Merus similar to that of large chela.

Ratio of articles of third maxilliped: 10:3:4. Second article 2 times as long as distal margin is wide. Distal tip with small brush of hairs.

Ratio of carpal articles of second leg: 10:4:3:3:4.

Ischium and merus of third leg unarmed; merus 4 times as long as broad. Carpus 0.6 as long as merus, superodistal margin projecting as a rounded tooth. Propodus 0.7 as long as merus, bearing on inferior margin 8 spines with a pair distally. Dactylus slender, 0.3 as long as propodus, in one specimen (BAU 33) bearing a small secondary unguis (fig. 13g, h) and another (JG 6-73) bearing a swelling on inferior surface at corresponding site.

Telson 2.5 times as long as posterior margin is broad. Anterior dorsal spines anterior to middle. Inner spines of posterolateral pair with length about equal to half breadth of posterior margin. External spine (not tooth) of outer uropod black.

DISCUSSION: While we have only 2 specimens clearly of this species from Australia (BAU 33, JG 6-73) we wish to review the "varieties" and subspecies of this species that have appeared in the literature. Heller's original type came from the Red Sea; De Man found his description defective and redescribed it in 1911. In 1905 Coutière described a variety *alluaudi* from the Seychelles and Maldives which was distinguished from Heller's species only by the lack of a secondary unguis on the dactylus of the third leg. In 1911 De Man also described the variety *luciparensis* from Indonesia which was separated from Heller's holotype by subtle differences in proportions. In 1953 the junior author described also as a variety (but subsequently used the name as a subspecies) a form from Hawaii under the name *simplex* that was separated from *A. gracilis gracilis* by the rostral carina, orbitorostral grooves, lack of tooth on the merus of the large cheliped, and with *A. g. alluaudi,* the lack of a secondary unguis on the dactylus of the third leg. He also pointed out that the variations found in the Hawaiian form would invalidate the criteria used by De Man for the separation of his variety (if, of course, populations from the Red Sea and Indonesia showed variation parallel to that in Hawaii).

In addition to the Australian specimens, we have studied the following specimens available to us in our various collections: 23 specimens from the Red Sea; 42 specimens from Thailand; 23 specimens from the southern Philippines; 8 specimens from Christmas Island (of the Line Islands, Pacific Ocean); 25 specimens from Maui, Hawaiian islands.

In these collections we found:

1. That while most specimens had deep orbitorostral grooves, those from Hawaii and Thailand appeared to be more shallow. However, in all groups there was variation and the impressions were subjective and could not be quantified. We also found that all groups of specimens, except those from Christmas Island, showed considerable variation in the relative length of the rostrum to the orbital teeth, but with the rostrum markedly longer than the teeth. In all 8 specimens from Christmas Island the rostrum was short, equal or subequal to the lengths of the teeth.

2. In all specimens examined there was a projection at the dactylar articulation of the small chela, but in groups from all localities this varied from a low obtuse tooth to a strong acute tooth as shown in figs. 13 e, k. The length-breadth ratio of the small chela varied from 3.5 to 4.5, a variation that could not be correlated with size, sex or locality.

3. All specimens from Thailand had no indication of a secondary unguis on the dactylus of the third leg (it should be noted that Tiwari figures a specimen from nearby Vietnam with a secondary unguis). Specimens from Hawaii had either a uniformly tapering dactylus or carried a swelling at the point where the secondary unguis would be expected; in one, however, the swelling was larger and definitely made an obtuse angle. In the small number of specimens from Christmas Island we found the condition varying from a slight rounded swelling through an angular projection to a strong definite tooth. Of the 23 specimens from the Philippines 3 had no secondary unguis, 4 had a slight

swelling, and the rest had a definite but small secondary unguis. All specimens from the Red Sea had strong and acute secondary ungui.

We conclude, therefore, that this species shows a tendency to develop morphologically separated geographic races or subspecies, but that this tendency is not definite enough to warrant the use of subspecific names, and we recognize only the nominate species.

The third specimen that we have listed as this species, a 15 mm female from BAU 29, is somewhat doubtful, for it differs from the other specimens we include in our review by a number of characteristics: the stylocerite only reaches to near end of first antennular article instead to the middle of the second; the blade of the scaphocerite is narrower; the third article of the third maxilliped is 3.5 instead of 7.0 times as long as broad, has a broader and more rounded tip and its tip bears setae longer than the article rather than markedly shorter; the merus of the chelipeds have the spines of the inferointernal margin replaced by setae and lack the terminal tooth; the small chela is somewhat heavier, 3.0 times as long as broad (but *A. gracilis* from the Red Sea run from 3.5 to 4.5 times as long as broad). It may have a different habitat, for it was collected from the rubble-strewn windward reef flat of Rudder Reef (off Port Douglas) where at times there is heavy direct surf action, while all *A. gracilis* we have been able to document did not occur in areas where the waves actually break. We consider the differences in the third maxilliped the most important. However, considering the variation in *A. gracilis,* and considering that there was only one somewhat defective specimen of this form, we are tentatively placing it under this species. We are illustrating this form in figure 13. Should additional specimens be collected and show constant characteristics, its separation should be reconsidered.

We agree with Barnard (1950:741) that both Stebbing's previous report of *A. gracilis* from South Africa and his own report of defective specimens that were possibly of this species are not firm enough to warrant extending the range of *A. gracilis* to include that area.

BIOLOGICAL NOTES: Coutière reported some colour notes on specimens from Djibouti (1898i:197)." . . . *gris rougeâtre, cette coloration étant disposée par bandes sur le corps et en macules irrégulierès sur les pinces*". Our specimens from Maui, Hawaii also have the reddish bands from near the middle of the carapace to the posterior end of the abdomen. We feel it is likely that this reddish brown banding is typical of *A. gracilis.* Most of the specimens we have seen have the external spine of the uropod coloured brown to black. This species has been collected inter- to subtidally and grows to a length of 35 mm.

AUSTRALIAN DISTRIBUTION: Two of our specimens came from off Port Douglas, Qld. and the other from Stradbroke Island, near Brisbane, Qld.

GENERAL DISTRIBUTION: This species has been recorded from many localities from the Red Sea and possibly South Africa, through the Indian Ocean and central Pacific to Hawaii and the Society Islands. We would expect to find it at least in the Ryukyus and possibly in southern Japan.

Alpheus facetus De Man

Fig. 14

Alpheus facetus De Man, 1908:100; 1911:340, fig. 67. Tiwari, 1963:288, fig. 9. Banner and Banner, 1966b:96, fig. 33.

SPECIMENS EXAMINED: 1 specimen each from AC 19, 28, 42, 58, 67, 81; 1, AM 21 (AM

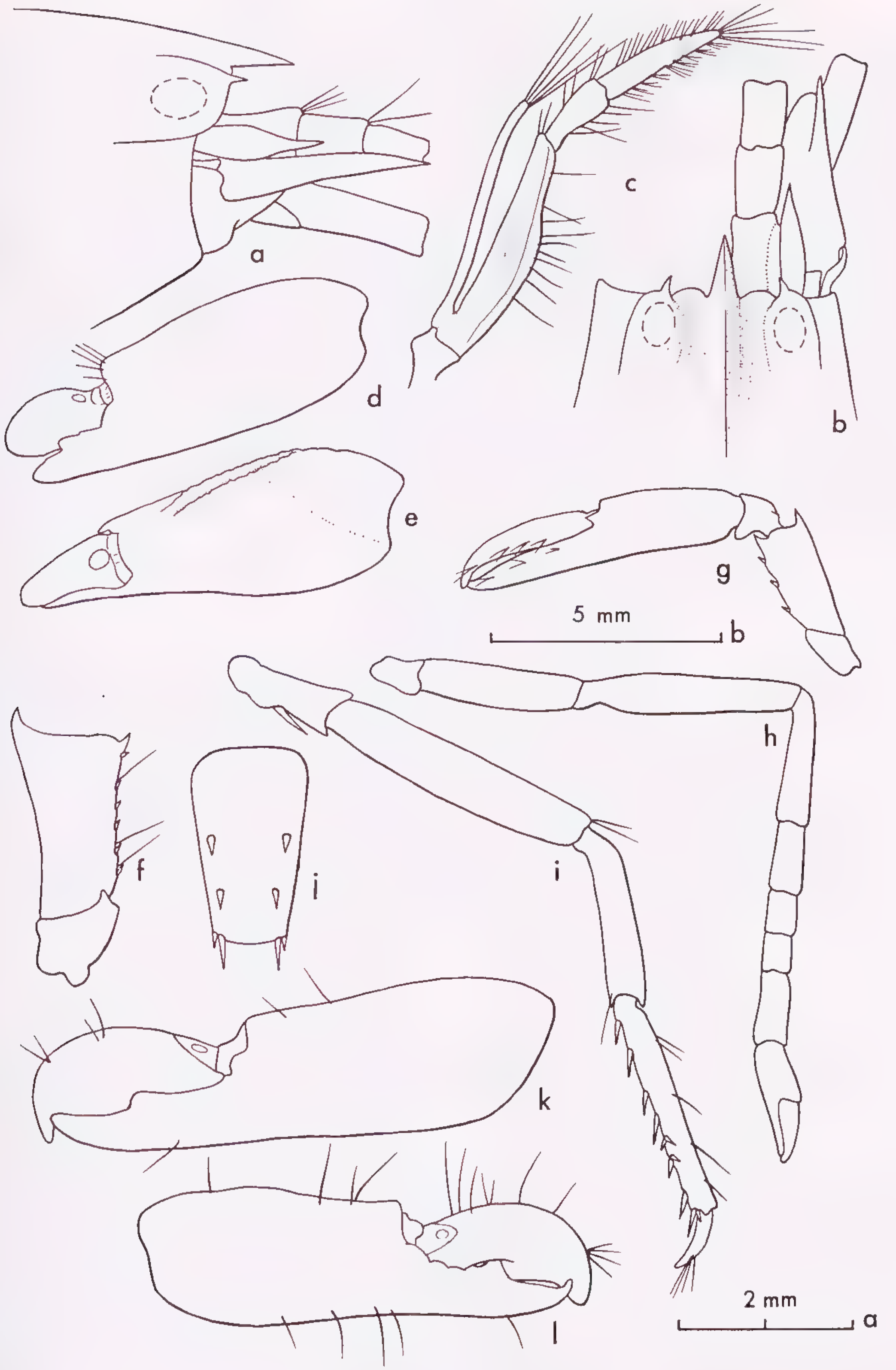

Fig. 14 *Alpheus facetus* De Man
15 mm male from BAU 56. **a, b.** Anterior region, lateral and dorsal view; **c.** third maxilliped; **d, e.** large chela lateral and superolateral face; **f.** merus of large cheliped, medial face; **g.** small cheliped, medial face; **h.** second leg; **i.** third leg; **j.** telson. 24 mm male from BAU 27. **k.** Large chela, lateral face. 22 mm male from BAU 28. **l.** Large chela, lateral face. a, b, c, f, h, i, j scale a; d, e, g, k, l scale b.

P. 27792); 1, AM 28 (AM P. 27551); 1, AM 33 (AM P. 27812); 1, AM 207 (AM P. 27563); 2, AM 283 (AM P. 27330); 1, AM 349 (AM P. 28147); 6, AM P. 2580; 1, AM P. 5314; 1, AM P. 6351; 1, AM P. 10534; 1, AM P. 27409; 1, AM P. 27569; 2, BAU 4; 2, BAU 10; 2, BAU 16; 1, BAU 21; 6, BAU 25; 8, BAU 27; 2, BAU 28; 1, BAU 32, 2, BAU 43; 4, BAU 44; 3, BAU 56; 2, JG 22-73; 1, MM 414; 1, WM 210-65; 2, WM 221-65.

DIAGNOSIS: Rostrum acute, 2 times as long as broad at base, reaching to end of first antennular article, with blunt carina that broadens slightly posteriorly and extends to near middle of carapace. Orbitorostral grooves broad and shallow, eye hoods only moderately inflated. Anterior margins of orbital hoods bearing teeth, 0.3 as long as rostrum and directed slightly inwards. Anterior margin between orbital teeth and rostrum with flattened prominences. Antennular articles nearly equal in length; second article 1.4 times as long as broad. Stylocerite with acute tip reaching to middle of second antennular article. Scaphocerite with lateral margins straight, lateral tooth extending slightly beyond antennules, squamous portion reaching to last quarter of third antennular article. Carpocerite reaching well past antennules, slightly longer than tooth of scaphocerite. Tooth on inferior margin of basicerite acute, broad at base and reaching to level of tip of rostrum.

Ratio of articles of third maxilliped: 10:3:5. Tip of third article bearing a tuft of long hairs.

Large chela slightly compressed, varying from 2.4 to 3.6 times as long as broad, with fingers varying from 0.4 to 0.6 times length of palm. Superior margin bearing 2 longitudinal ridges with a depression between which begin near proximal fifth and extend obliquely, to near distal fifth of palm where they disappear. This groove is often faint and at times missing entirely. Inferior margin rounded without notches or grooves. Merus 1.8 times as long as broad, superior margin bearing distally a broad acute tooth, inferointernal margin bearing from 4-6 small spines and a small acute tooth distally.

Small chela not sexually dimorphic, 4.6 times as long as broad with fingers and palm equal. Palm bearing slightly medially an acute tooth at dactylar articulation. Merus 2.3 times as long as broad, similar in armature to large chela.

Ratio of carpal articles of second leg: 10:5:3:3:5.

Ischium of third leg with spine. Merus 5 times as long as broad, unarmed.

Carpus 0.6 as long as merus, distal angles slightly projecting. Propodus 0.8 as long as merus, bearing on its inferior margin 9 spines with a pair distally. Dactylus 0.23 as long as propodus, simple.

Telson 2.7 time as as long as posterior margin is broad, first pair of dorsal spines placed just anterior to middle, inner spine of posterolateral pair long and slender, length almost half length of posterior portion.

DISCUSSION: The specimens exhibited some variation. The rostrum varied from shorter than to slightly longer than, the first antennular article. The palm of the large chela varied from 1.4 to 2.3 times longer than the fingers with the majority of specimens having the palm over 2 times longer than the fingers. There were only 3 specimens in which the fingers were unusually long and we have figured 2 (fig. 9k, 1). The dactylus of all the specimens, except those with the longer fingers, was truncate. Since the three specimens with the longer fingers resembled the other specimens in the collection almost exactly we considered this a variation. The specimen from BAU 27 came from a collection of seven of normal proportions from the same location. In a collection of 25 specimens of this species we made in the Philippines there was also one specimen in

which the palm was 1.5 times longer than the fingers. The first two articles of the second legs in our specimens varied from 10:5.5 to 10:4.7.

BIOLOGICAL NOTES: This species has been collected from intertidal to depths of 30 metres, but most specimens have come from dead coral heads collected in 6 metres or less depths.

A specimen from Hayman Island (BAU 43) was reported as having "two longitudinal brown bands separated mid-dorsally by a pinkish tan band. Chelae more or less a continuation of the brown band. Tail fan dark at base, then with a light band adjacent to this, and the tail terminated in a dark green band". Yaldwyn has supplied similar colour notes for a specimen from the Gulf of Carpentaria (AM 28). Our largest specimen was 28 mm in length.

AUSTRALIAN DISTRIBUTION: We have specimens from Western Australia from near Perth north to Yampi Sound. In northern Australia from Darwin, the Gulf of Carpentaria and Thursday Island; in eastern Australia from off Port Douglas south to near Sydney, N.S.W.

GENERAL DISTRIBUTION: Viet Nam; Thailand; Indonesia; Philippines.

Alpheus lottini Guérin
Fig. 15

Alpheus Lottini Guérin, 1829:pl. 3, fig. 3.

Alpheus Lottinii Guérin, 1838:38. Kingsley, 1882:113.

Alpheus lottini Holthuis, 1958:22; 1961:168. Tiwari, 1963:285, fig. 8. Banner and Banner, 1966b:91, fig. 31.

Alpheus ventrosus Milne-Edwards, 1837:352.

Alpheus laevis Randall, 1839:141.

Alpheus Thetis Miers, 1874:5, pl. 4, fig. 7 (=*A. Thetis* White, a *nomen nudum*) (New Holland).

Crangon latipes Banner, 1953:82, fig. 27 (juvenile form).

Crangon ventrosa Banner, 1953:83, fig. 28

Previous Australian records:
Heller, 1865:107. Sydney (as *A. laevis).*
Haswell, 1882b:191. Sydney (as *A. laevis*).
Coutière, 1900:413. Murray Is. (as *A. ventrosus*).
Patton, 1966:282. Queensland (as *A. ventrosus*).
McNeill, 1968:15. N. Queensland (as *A. ventrosus*).

SPECIMENS EXAMINED: 1 specimen from AC 15; 1, AC 17; 1, AC 61; 1, AC 62; 1, AH 5; 1, AM 29 (AM P. 27299); 4, AM 58 (AM P. 27300); 4, AM 74 (AM P. 27502); 1, AM 83 (AM P. 27301); 2, AM 99 (AM P. 27770); 14, AM 123 (AM P. 27302); 4, AM 147 (AM P. 27303); 2, AM 171 (AM P. 27503); 1, AM 174 (AM P. 27525); 1, AM 186 (AM P. 27304); 2, AM 238 (AM P. 27305); 2, AM 268 (AM P. 28103); 1, AM 275 (AM P. 27405); 9, AM 283 (AM P. 27306); 3, AM 294 (AM P. 27307); 3, AM 305 (AM P. 27773); 1, AM 341 (AM P. 27332); 4, AM 342 (AM P. 27333); 1, AM 400 (AM P. 27334); 1, AM G. 3283; 3, AM P. 2578; 1, AM P. 6862; 1, AM P. 7309; 3, AM P. 7422; 1, AM P. 7454; 6, AM P. 7524; 1, AM P. 7981; 1, AM P. 8026; 3, AM P.

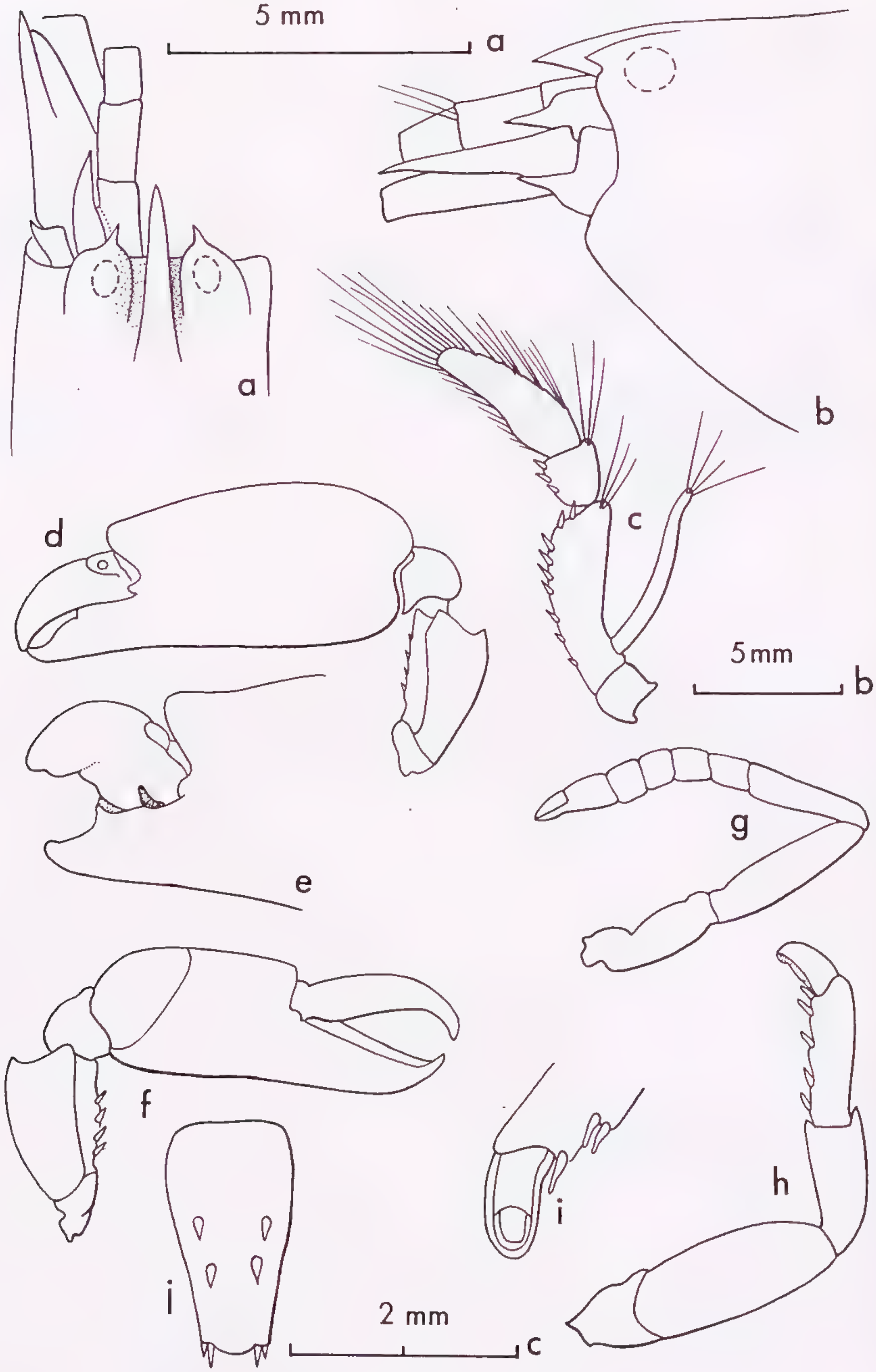

Fig. 15 *Alpheus lottini* Guérin
29 mm male from AMP 8026. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d, e.** large cheliped and enlarged distal region; **f.** small cheliped, lateral face; **g.** second leg; **h, i.** third leg and enlarged dactylus, inferior face; **j.** telson. a, b, c, e, g, h, j scale a; d, f scale b; i scale c.

8567; 3, AM P. 10322; 2, AM P. 11401; 1, AM P. 13547; 1, AM P. 13573; 1, BAU 3; 1, BAU 4; 1, BAU 15; 1, BAU 16; 1, BAU 24; 1, BAU 27; 1, BAU 32; 2, BAU 38; 4, BAU 44; 2, BAU 47; 3, BAU 48; 1, BAU 52; 1, BAU 57; 1, JC 23; 2, MM 111; 1, MM 263; 1, MM 421; 2, QM W. 999; 2, VM 2; 1, WM 23-65; 1, WM 118-65; 2, 75 LIZ-S (AM P. 27918).

DIAGNOSIS: Rostrum slender, acute, reaching to end of first article of antennular peduncle. Rostral base broadened, flattened, not carinate dorsally, separated from carapace by deep and narrow sulci on each side. Orbital hoods rounded laterally, bearing acute teeth on more medial portion of hood, teeth directed slightly inward. Antennular peduncle slender, with second article variable but usually 1.7 times as long as broad, only slightly longer than visible portion of first or third. Stylocerite reaching to middle of second antennular article. Scaphocerite long with narrow squamous portion reaching just beyond end of antennular peduncle and with lateral tooth reaching well past end. Carpocerite subequal to length of scaphocerite. Lateral spine of basicerite acute, equal to or exceeding length of stylocerite.

Third maxilliped stout, articles with a ratio: 10:3:8. Inferior margin of both first and second article bearing spines, superior margins bearing coarse setae distally.

Large chela compressed, margins rounded, without grooves or crests, 2.5 times as long as broad. Dactylus not strongly arcuate, in males 0.3 length of entire chela with tip acute and hooked; in females dactylus rounded at tip, only 0.2 length of entire chela. Merus with both superior and inferointernal angles rounded, although projecting; inferointernal margin with about 5 spines.

Small chela almost as long as large chela but more slender, varying from 2.5 to 3.0 times as long as broad; fingers about equal in length to palm. Dactylus strongly curved at tip, crossing fixed finger when closed. Inner margin of cutting face of fixed finger with distinct lamellar ridge along entire length. Merus similar to that of large cheliped.

Ratio of carpal articles of second leg: 10:6:6:6:5; last four articles almost as broad as long.

Ischium of third legs inermous. Merus inermous, over 3 times as long as wide. Carpus with both margins continued as heavy projections. Propodus with 5-7 spines, with broadened, flattened tips. Dactylus heavy, blunt, laterally compressed, with thick longitudinal ridge on inferior face continuing around blunt tip as a curving ridge, the blunt tip thus carrying a ridge of hard chitin similar in form to a horses hoof; portion of dactylus surrounded by ridge of soft flexible chitin.

Telson 3.3 times as long as broad at posterior end. First pair of dorsal spines placed just anterior to middle. Inner pair of posterior spines nearly same size as dorsal spines.

DISCUSSION: This well-known species has been figured and described many times and has been known by 4 names. Coutière in 1899 (p. 12) placed *A. laevis* into synonymy to *A. ventrosus*; Holthuis in 1958 (p. 12) reviewed the synonymy and accepted Kingsley's (1882:113) decision that *A. ventrosus* was a junior synonym of *A. lottini* Guérin. Holthuis (1957, 1961) also discussed the dates of publication of Guérin's plate bearing the name *Lottini* (in his 1838 description he spelled it *Lottinii*). The junior author also created a synonym, *Crangon latipes*, based on a juvenile specimen markedly different from the adult (1953:82); this was corrected in a subsequent paper (1958:165). Finally we have reported that the largely unused name *A. thetis* White is a synonym of *A. lottini* (B&B, 1977:282).

This species is most easily recognized and the most surely identified in its adult form in the whole genus by the unique development of the dactyls of the walking legs; smaller

specimens found in symbiosis with living pocilloporid corals which do not have this development should be carefully compared to the description of the juvenile form (*loc. cit.*) and with the other symbiont of the same corals, *Synalpheus charon* (Heller) (B&B, 1975:369).

BIOLOGICAL NOTES: This species is an obligate symbiont, living exclusively in living heads of the members of the Pocilloporidae, especially *Pocillopora meandrina* var. *nobilis* Verrill, *P. ligulata* Dana, large colonies of *P. damicornis* (Linnaeus) (=*P. cespitosa* Dana) and some of the species of the genus *Seriatopora* (the last reported by Patton, 1966). This species, together with crabs of the genus *Trapezia*, is found in various parts of the branching colonies, but retire deeply between the branches when disturbed. Also in the same heads, but apparently confined to the unbranched base is the smaller *Synalpheus charon* (Heller). All three symbionts are of similar colour, a mottled bright orange-red ground color with a dark red mottling. *A. lottini* also may bear a mid-longitudinal stripe of deep red that may appear almost black.

In most of the Australian collections the exact depth at which the specimens were collected was not often clearly indicated, but as the host corals cannot survive much intertidal exposure, most must have been subtidal, and extending down to the depth limits of the host. The specimens range in size up to 38 mm.

AUSTRALIAN DISTRIBUTION: We have a few specimens from western Australia from near Perth to the Dampier Archipelago. In North Australia we have specimens from Darwin and the Torres Straits, but the majority of specimens range from Princess Charlotte Bay in north Queensland to Sydney. We also have 4 specimens from Lord Howe Island. There were no specimens from South Australia or Tasmania in our collections.

GENERAL DISTRIBUTION: This species is one of the most widespread species of the Indo-Pacific appearing, it would seem, wherever the host corals appear, from the head of the Red Sea to east and South Africa, through the Indian and Pacific Oceans, and even extending beyond the Eastern Pacific Barrier to the mouth of the Gulf of California. It would be expected to occur in the Ryukyus and Southern Japan as the genus *Pocillopora* appears there, but it has not yet been so reported.

Alpheus socialis Heller
Fig. 16

Alpheus socialis Heller, 1865:106, pl. 10, fig. 1. Thomson, 1903:436, pl. 27, figs. 6-12.

Alpheus doto White, 1847:75. *(nomen nudum).*

Previous Australian records
Haswell, 1882b:190. Sydney.
Sayce, 1902:155. Port Phillip, Victoria.

SPECIMENS EXAMINED: 1 specimen from AM 32 (AM P. 27872); 4, AM 49 (AM P. 27867); 1, AM 76 (AM P. 27845); 7, AM 93 (AM P. 27890); 6, AM 122 (AM P. 27873); 1, AM 150 (AM P. 27843); 2, AM 192 (AM P. 27846); 2, AM 214 (AM P. 27933); 1 AM 220 (AM P. 27866); 1, AM 233 (AM P. 27844); 1, AM 289 (AM P. 27847); 2, AM 383 (AM P. 27876); 1, AM 388 (AM P. 27868); 1, AM 395 (AM P. 27848); 1, AM 398 (AM P. 27849); 2, AM P. 3072; 1, AM P. 5029; 1, AM P. 5711; 1, AM P. 6309; 2, AM P. 6526; 3, AM P. 6912; 1, AM P. 8438; 3, AM P. 10092; 1, AM P. 10114; 15, AM P. 11734; 1, AM P. 13546; 1, AM P. 13560; 4, AM P. 13580; 1, AM P. 27874; 2, AM P. 27877.

DIAGNOSIS: As this species is so like *A. parasocialis sp. nov.*, described and figured

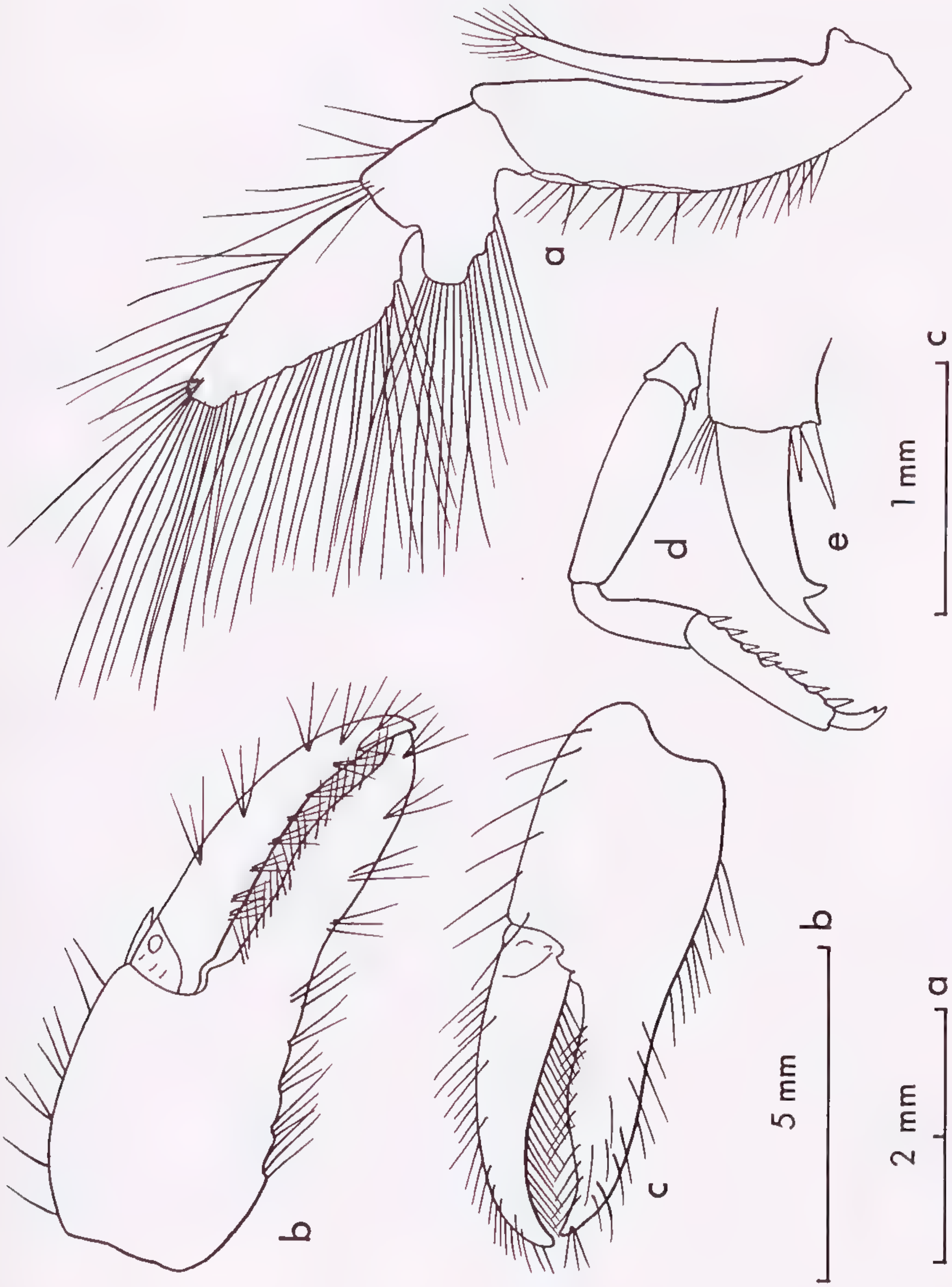

Fig. 16 *Alpheus socialis* Heller
25 mm male from AM 388. **a.** Third maxilliped; **b, c.** small chela, lateral and medial face; **d, e.** third leg and enlarged dactylus. a scale a; b, c, d scale b; e scale c.

below a new full description and figures are not given. Figure 16 illustrates the characteristic features of *A. socialis.*

DISCUSSION: The separation of this species from *A. sulcatus* Kingsley and those related to it in Australian waters is given on Table 1 (p. 86). It is most closely related to *A. parasocialis* B&B and the separation of these 2 species is discussed on p. 73.

Heller did not designate a holotype and give its locality, but instead designated a syntypic series from New Zealand and Australia (''*Fundort:* Auckland, Sydney''). The species was completely redescribed by Thomson (1903:436, figs. 6-12) using specimens from New Zealand. As neither author mentioned the unique lobe on the second article of the third maxillipeds, and as *A. socialis* and *A. parasocialis* may coexist in the Sydney area, we were undecided as to which species should bear the name given by Heller. We were unable to find Heller's type material, but we reasoned that if only one of two species occurs in New Zealand it is likely that one would be the true *A. socialis.* Dr John Yaldwyn of the National Museum at Wellington compared specimens from Australia that we sent him with those from New Zealand, and in turn sent us some New Zealand specimens for our study. Dr Yaldwyn found that only the form with the lobe on the third maxilliped and other characteristics of this species occurs in New Zealand, so we are designating this form as *A. socialis.*

It is worthy to note that White's *A. doto,* a *nomen nudum* that he reported from Sir C. Hardy's Island from the northern portion of the Great Barrier Reef (approximately 11°56'S:143°29'E) is plainly this species for, in spite of its desiccated condition, it shows the characteristic lobe on the third maxilliped (B&B 1977:282). We are unable to account for this extreme extension of the range of a species that has otherwise been limited to temperate waters in Australia; we suggest the label may be in error.

BIOLOGICAL NOTES: The majority of specimens in these collections were obtained intertidally. However, Yaldwyn sent us a well preserved specimen from off the southern part of South Island, New Zealand that was collected from 60 fathoms.

Yaldwyn supplied the following colour notes for a specimen collected from Long Reef (AM 192). ''A small green specimen with a 'W' mark on big hand and had the following general coloration in life: overall colour pale green, incipient darker green band posteriorly on each abdominal segment. Large hand with broad green 'W' on white background''. Yaldwyn also reported to us in a personal communication that in a collection of 6 fresh specimens that were collected in 18 fathoms of water off Cape Colville, in the Auckland area, he had found the same distinctive 'W' on the upper face of the large chela. However, all other specimens he had seen from New Zealand had a completely different colour pattern on the large chela. ''. . . both hands are orange to purple with a series of large scattered white spots on their upper faces''. Yaldwyn sent us several specimens with the latter colour pattern and we compared them with a preserved specimen from Long Reef and were able to detect no morphological differences. We can only assume that the color pattern in *A. socialis* is not a reliable character for identification. Specimens range in size up to 35 mm.

AUSTRALIAN DISTRIBUTION: All of our specimens of *A. socialis* came from the coast of New South Wales, largely from the Sydney area with 9 additional specimens coming from Lord Howe Island. This species appears to be restricted to these areas; it overlaps with *A. parasocialis* only in New South Wales.

GENERAL DISTRIBUTION: Ony Australia, Lord Howe Island and New Zealand.

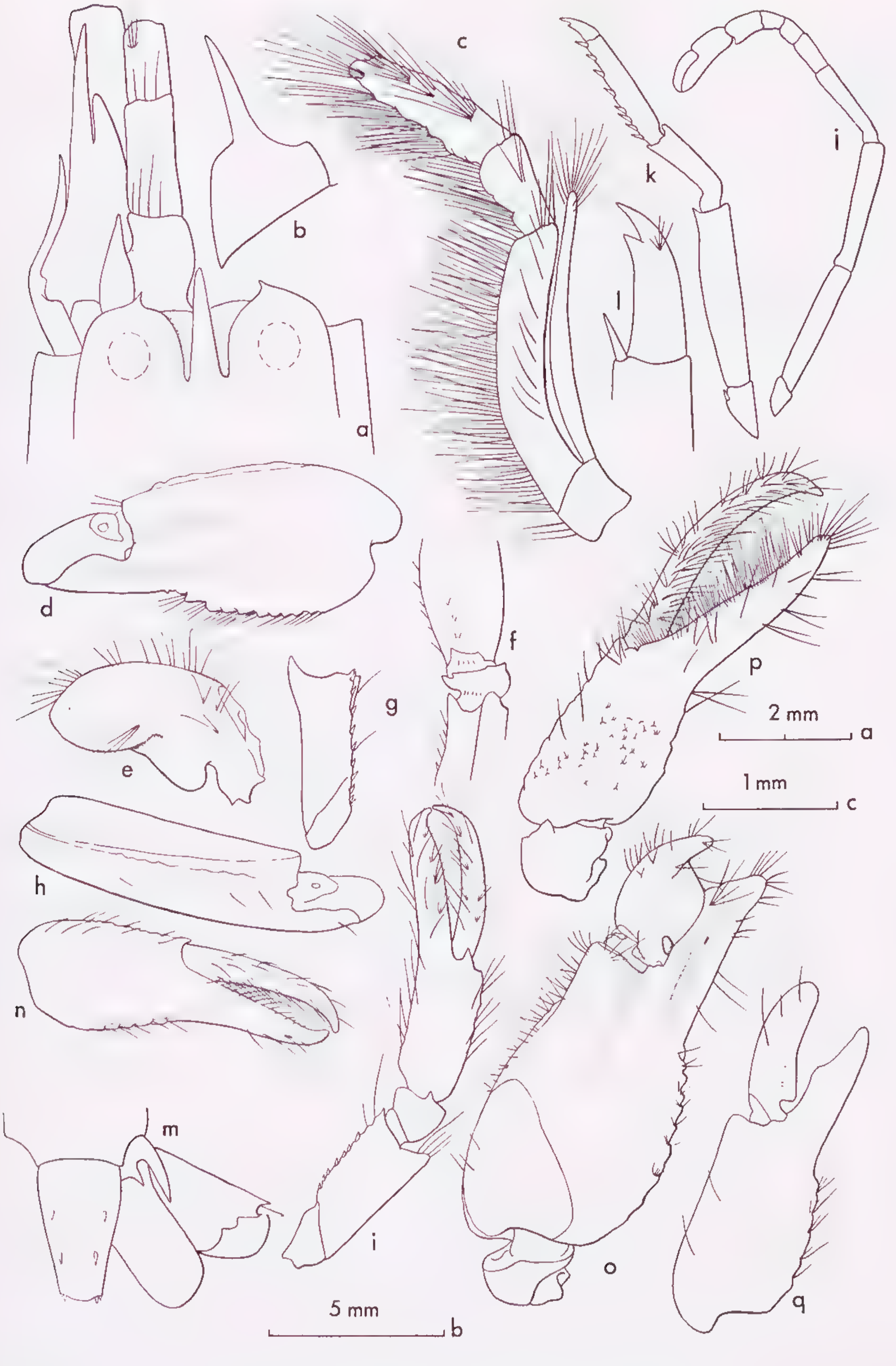

Fig. 17 *Alpheus parasocialis* sp. nov.
Holotype (female). **a.** Anterior region, dorsal view; **b.** basicerite, inferolateral face; **c.** third maxilliped; **d, e.** large chela and dactylus, lateral face; **f.** carpus of large cheliped, inferior face; **g.** merus of large cheliped, medial face; **h.** large chela, superior face; **i.** small cheliped, medial face; **j.** second leg; **k, l.** third leg and dactylus enlarged; **m.** telson and uropods. Allotype (male). **n.** Small chela, medial face. 28 mm male from WM 143-65; **o.** Large chela, lateral face; **p.** small chela, medial face. 30 mm female from WM 182-65. **q.** Large chela, lateral face. a, b, c, e scale a; d, f, g, h, i, j, k, m, n, o, p, q scale b; l, scale c.

Alpheus parasocialis sp. nov.*
Fig. 17

HOLOTYPE: 34 mm female from Palm Beach, Rockingham, W.A. Collected by P. Barrett-Lennard from jetty piles, 1959. (WM 288-65).

ALLOTYPE: 32 mm male specimen from same locality as holotype.

PARATYPES: 2 specimens from AC C-1; 2, AC C-29; 1, AC C-50; 1, AC 41; 1, AC 52; 1, AC 65; 1, AC 76; 1, AC 77; 2, AM 75 (AM P. 27249); 1, AM 182 (AM P. 27250); 2, AM 229 (AM P. 27251); 5, AM E. 5679; 4, AM P. 2329; 1, AM P. 12427; 1, AM P. 13578; 1, AM P. 27256; 10, AM P. 27257; 1, AM P. 27258; 3, AM P. 27259; 1, AM P. 27260; 1, AM P. 27261; 1, AM P. 27936; 1, BAU 3; 3, BAU 4; 1 specimen each from CS. 33, 34, 35, 36; 2, MM 204; 3, QV1971-10-6; 1, SM 2; 1, TM G1482; 1, TM G1509; 1, TM G1510; 2, TM G1538; 1, VM 21; 1, VM 22; 1, WM 23-65; 2, WM 29-65; 2 WM 38-65; 1, WM 42-65; 4, WM 58-65; 3, WM 87-65; 4, WM 95-65; 1, WM 97-65; 1, WM 103-65; 1, WM 108-65; 1, WM 109-65; 1, WM 111-65; 2, WM 112-65; 1, WM 113-65; 6, WM 117-65; 1, WM 120-65; 2, WM 121-65; 1, WM 130-65; 1, WM 135-65; 2, WM 143-65; 1, WM 159-65; 2, WM 182-65; 1, WM 198-65; 1, WM 200-65; 1, WM 201-65; 2, WM 202-65; 1, WM 203-65; 1, WM 228-65; 1, WM 240-65; 1, WM 248-65; 1, WM 257-65; 3 WM 266-65; 1, WM 267-65; 1, WM 269-65; 4, WM 288-65; 4, WM 153/173-31; 3, WM 4985; 1, WM 10011; 2, WM 10381; 1, WM 10467; 5, WM 10571/72; 1, WM 11100/1; 3, WM 251/78-32.

DIAGNOSIS: Rostrum acute, about 3 times as long as broad at its base, reaching variously from first quarter to near end of visible part of first antennular article, without rostral carina. Orbits moderately inflated, orbitorostral grooves deep, recessed under rostrum from anterior margin to base of rostrum. Middle of anterior border of eye hoods bearing short acute teeth that turn medially. Orbitorostral border convex. Visible part of first and third antennular article subequal; second article 1.4 times longer than third article and 2.4 times as long as broad. Stylocerite reaching to end of first antennular article. Outer margin of scaphocerite concave in proximal section, lateral tooth strong and reaching to end of antennular peduncle, squamous portion reduced in breadth and only slightly longer than second antennular article. Carpocerite slightly longer than scaphocerite. Inferior margin of basicerite bearing strong tooth reaching to middle of second antennular article.

Articles of third maxilliped with ratio: 10:2.5:7. Inferior face of all 3 articles bearing profuse long sweeping hairs, tip with a brush of long hairs. Second article with only slight distal broadening, third article with slight taper.

Large chela 2.5 times as long as broad with fingers occupying distal 0.3. Tip of dactylus usually heavily rounded, but at times subacute. Superior margin bearing a longitudinal groove extending from proximal portion of palm and disappearing near dactylar articulation. Medial side of groove with bosses bearing sprinkling of hairs. Outer face of palm with 2 shallow grooves, the superior arising mid-palm and extending to dactylar articulation, the inferior arising near a slight "notch" in inferior margin and continuing on pollex to distal margin of socket. Inferior margin bearing a series of bosses carrying short stiff setae. Plunger of dactylus essentially cylindrical in section with tip truncate at an angle and connected on medial side to distal bulbous portion of dactylus by

*While we are aware that the prefix *para* is Greek and the root *socialis* is Latin, and that the combination of Greek and Latin into a single name is not recommended by the International Commission, we are making the combination deliberately to show what we think is a close relationship, and such relationship cannot be simply expressed in Latin. We have a similar combination for the same reason in *Synalpheus paralaticeps* (p. 291). We also point out that similar combinations have been used in the past, as in *M. paragracilis*.

thin ridge; socket distally with narrow but deep "v"-shaped incision to accommodate ridge. Carpus cup-shaped, 0.4 as long as merus, bearing just proximal to inferior margin of chela a small acute tooth, at times of minimal development. Merus twice as long as broad with distosuperior margin projecting as subacute tooth; inferior margin bearing 7-8 small spines and a small acute tooth distally. Ischium bearing 3 spines on inferior margin similar to those of merus.

Small chela with slight sexual dimorphism, varying from 3.0 to 3.6 times as long as broad, with that of female usually more slender than that of male. Fingers and palm nearly equal. Palm bearing an acute tooth over dactylar articulation. Inferior and superior margin bearing bosses similar to those of large chela. Finger hirsute, at times with hair so dense as to obscure cutting surface on medial face. Merus similar to that of large chela, but distosuperior margin is not projected.

Ratio of carpal articles of second leg: 10:5:2:2:4.

Ischium of third leg bearing small spine. Merus 4.6 times as long as broad, usually with inferior margin projecting as small acute tooth. Carpus 0.5 as long as merus, both distal margins projecting. Propodus 0.7 as long as merus, bearing on inferior margin 7 spines and a pair distally. Dactylus 0.3 as long as propodus, biunguiculate.

Telson 3.2 times as long as posterior margin is broad. Anterior pair of dorsal spines placed anterior to middle. Posterolateral spines the same size as dorsal spines. Articulation on outer uropod scalloped.

DISCUSSION: This species is plainly closely related to *A. sulcatus* Kingsley and to other species so related; the separation of these is given in Table 1. Its closeness to *A. socialis* Heller is most great, and it can be separated by only four characteristics, three of which may be variable. The most reliable and important is the form of the distal articles of the third maxilliped. In *A. parasocialis* the second article is only slightly expanded distally and the third has a slight taper from the base to the tip. In *A. socialis* the development of these articles is unique, with the second bearing a massive, diagonally-truncate lobe, and the third article expanding broadly in the initial third and distally tapering rapidly to a narrow tip; both the lobe and the inferior side and tip of the third article bears many setae about as long as third article. In addition the carpus of the large chela bears a tooth on the inferodistal margin that is lacking in *A. socialis,* the small chela of the male and female varies from 2.4-3.0 times as long as broad in this species and bears a meral tooth like the large cheliped while in *A. socialis* it is stouter, 3.0-4.0 times as long as broad, and lacks the distal tooth.

We believe this species, as it is more generalized and more broadly spread (with the exception of the New Zealand range of *A. socialis*) to be the form from which *A. socialis* was derived. If our hypothesis about *A. parasocialis* being derived from *A. sulcatus* is correct (see discussion under that species) it is notable that this species, having adapted to the cold Australian waters, has re-entered warmer waters both in eastern and western Australia where its range overlaps that of *A. sulcatus*. Its range also overlaps with *A. socialis* in New South Wales and extends on either side of *A. australosulcatus sp. nov.*, known only from Tasmania.

Of the 130 specimens in our collection, 60 complete specimens were carefully studied for variation. It was found that the third maxilliped was at times much more hirsute on the inferior margin than at other times. The distal tip of the dactylus of the large chela varied from heavily rounded (fig. 17d) to a definite but rounded tooth. The small chela varied from 3.0-3.8 times as long as broad and usually that of the female was more slender. The merus of the third leg varied from 4.2 to 4.6 times as long as broad and the

distal tooth varied from a small acute tooth to a sharp angle and in 14 of the specimens the tooth was entirely lacking.

One specimen from Lancelin Is., W.A. (WM 143-65) and one from Tasmania (TM G1538), both males, differ from the usual *A. parasocialis* in the form of their chelae. On the large chela the palm is normal for the species, but the dactylus is acute at its tip and the plunger is massively developed, and instead of being cylindrical with a thin distal ridge, tapers only slightly distally from maximum diameter to broadly rounded edge. When the article is viewed from the superior aspect, the distal portion of plunger is seen to make a heavy shoulder on the medial side of the article. Correspondingly the narrow distal incision of the socket is here a broad and deep "U"-shaped depression to accommodate the heavy distal extension. In the small chela the fingers were much more hirsute than is usual and appear almost sub-balaeniceps (fig. 17p) but did not have the orderly rows of setae as in *A. australosulcatus*, and the constriction on the inferior margin opposite the articulation of the dactylus was more pronounced than is usual. However, the rest of the characteristics were like those of the holotype and the Tasmanian male was in the same collection as a normal female. We therefore suggest that these differences may be an extreme variation. In one specimen from Houtman Abrolhos (WM 185-65) the plunger of the dactylus of the large chela was only of minimal development (fig. 17q) and the fingers were nearly 0.8 as long as the palm instead of 0.4 as in the typical specimen. The rest of the specimen was usual. This may be due to a regenerating large chela.

BIOLOGICAL NOTES: Most of these specimens have been collected intertidally, but a few came from as deep as 16 fathoms. One specimen was reported from a sponge. The following colour notes were supplied by James and Davemport for 2 specimens from Houtman Abrolhos (AC C-1) "Transparent body. Orange chela with red tips. Red to orange on each abdominal segment. Orange to red carapace". Our largest specimen was 35 mm.

AUSTRALIAN DISTRIBUTION: The species ranges from Moreton Bay south and west along the entire southern coast of Australia, including Tasmania, and northward on the western coast to Shark Bay. No specimens came from the coast of Victoria, but it certainly should be expected to occur there.

DISTRIBUTION OF TYPE MATERIAL: The holotype and allotype will be returned to the Western Australian Museum and the paratypes to their respective museums.

Alpheus amirantei sizou Banner and Banner

Fig. 18

Alpheus amirantei sizou Banner and Banner, 1967:265.

Crangon amirantei Banner, 1953:87, fig. 29.

Confer: *Alpheus amirantei* Coutière, 1908a:15, 1921:421, pl. 63, fig. 16.

SPECIMEN EXAMINED: 1 specimen from AM 109 (AM P. 27507).

DIAGNOSIS: Rostral carina high, sharp and narrow between eyes, abruptly curving ventrally to short free portion of rostrum; tip of rostrum reaching to end of first third of visible part of first antennular article, posteriorly carina reaching only to posterior end of orbital hoods. Orbital hoods inflated, projecting anteriorly into round vertical keel. Orbitorostral margin almost straight, orbitorostral grooves flattened. Carapace inflated over antennular bases, leaving groove between bases

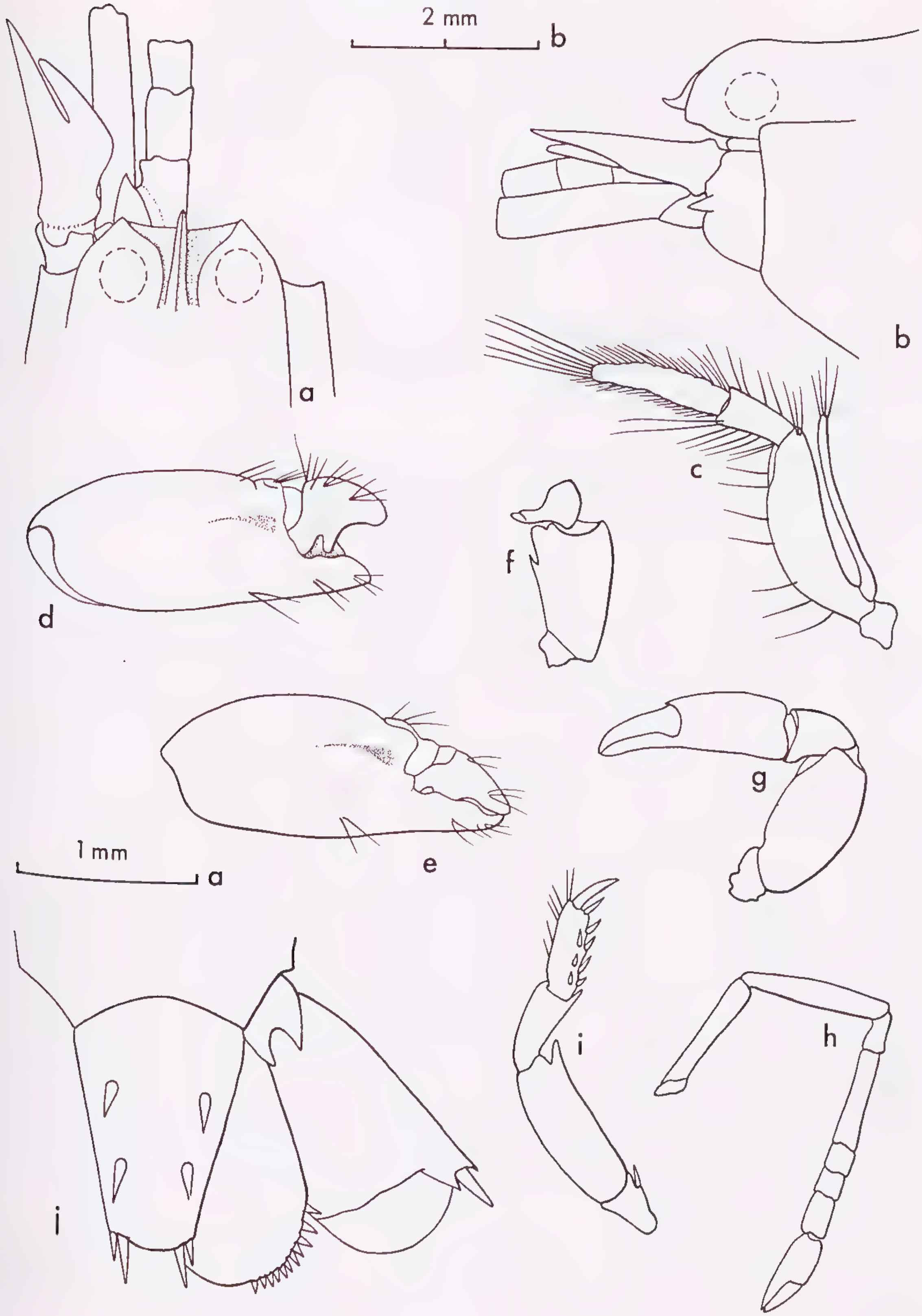

Fig. 18 *Alpheus amirantei sizou* B&B
11 mm female from AM 109. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d, e.** large chela, lateral and superolateral faces; **f.** merus, large cheliped, lateral face; **g.** small cheliped, lateral face; **h.** second leg; **i.** third leg; **j.** telson and uropods. a, b, c, j scale a; d, e, f, g, h, i scale b.

and orbital hoods. Visible part of first antennular article as long as second; second 1.4 times as long as broad; third article 0.7 length of second. Stylocerite acute, tip not reaching end of first antennular article. Outer margin of scaphocerite slightly concave, lateral tooth reaching well beyond antennular peduncle, squamous portion narrow and reaching to end of antennular peduncle. Carpocerite reaching almost length of third article past that article. Lateral tooth of basicerite moderately developed, acute.

Large chela sub-cylindrical, 2.4 times as long as broad with fingers occupying distal third. Dactylus heavy with rounded tip. Palm bearing small, poorly defined transverse groove proximal to dactylus, and a small but at times V-shaped longitudinal groove on lateral face running from near middle of palm to near palmar adhesive plaque. Inferior margin entirely without constriction or grooves. Merus 1.8 times as long as broad, superodistal margin rounded, inferointernal margin usually bearing sub-terminally small acute tooth.

Small chela of female three times as long as broad with fingers slightly shorter than palm. Merus two times as long as broad, broadest in middle, without teeth on inferodistal margins. Male chela similar, but larger in proportion to specimen.

Carpal articles of second leg with ratio: 10:22:6:6:10.

Third leg stout, ischium with strong spine. Merus 2.8 times as long as broad, bearing distally a strong sub-terminal tooth. Carpus 0.5 as long as merus with inferodistal margin terminating in a strong acute tooth and superodistal margin terminating in a rounded tooth. Propodus 0.6 as long as merus, inferior margin bearing about 10 spines in two irregular rows. Dactylus simple, strong and slightly curved, 0.2 as long as merus.

Telson three times as long as posterior margin is broad, first pair of dorsal spines placed anterior to middle; inner spines of posterior pair twice as long as outer. Inner uropod with numerous strong spines on distolateral curve.

DISCUSSION: It should be noted that when the dactylus of the large chela is fully flexed (as in fig. 18d) it appears hammer-shaped, but when seen fully closed (as in fig. 18e) it appears to be more or less "normal" with a closure along the length of the pollex, not with its bulbous tip closing over end of the pollex as is found in "true" hammer-shaped dactyli (as in the Obesomanus Group).

We separated *A. amirantei sizou* from the central Pacific from the nominate *A. amirantei* of the central Indian Ocean by a series of characteristics; this small Australian specimen clearly is of the central Pacific form and shows all of the characteristics that were used in the separation. However, since the original description we have found greater variation than that originally reported in specimens from the Pacific and may wish to review the separation should we have available a larger series showing comparable variation from Indonesia and the Indian Ocean.

BIOLOGICAL NOTES: In the central Pacific this species has been collected exclusively in the intertidal and the shallow sub-tidal zones; this specimen was taken from "coral washings" at Herald Cay in the same depth zone (J. C. Yaldwyn, personal communication).

AUSTRALIAN DISTRIBUTION: Our sole specimen was collected in the Herald Group, Coral Sea.

GENERAL DISTRIBUTION: Marshall Islands; Tonga; Line Islands; Tahiti; Rarotonga (not previously reported). The nominate species is known only from the Seychelles and the Maldives.

Alpheus acutofemoratus Dana

Fig. 19

Alpheus acutofemoratus Dana, 1852:550, pl. 35, fig. 2. De Man, 1902:888, pl. 27, fig. 63. Banner and Banner, 1966b:87, fig. 29.

Alpheus parabrevipes Coutière, 1898c:151.

Nec Alpheus acutofemoratus Bate, 1888:545, pl. 97, fig. 2. [Cape York]. (=?).

SPECIMENS EXAMINED: 2 specimens from BAU 24; 1, BAU 27; 3, BAU 28; 11, BAU 55.

DIAGNOSIS: Rostrum small, triangular, slightly depressed between orbital hoods, with broad, rounded carina broadening posterior to base of hoods and merging with carapace. Rostrum reaching middle of visible part of first antennular article. Orbitorostral margin concave lateral to base of rostrum, orbital margin convex. Visible part of first antennular article and third article sub-equal; third article 0.7 length of second; second 1.8 times as long as broad. Stylocerite acute, not reaching quite to end of first antennular article. Lateral margin of scaphocerite strongly concave, with strong lateral tooth reaching well past end of antennular peduncle, squamous portion narrow, reaching slightly beyond end of antennular peduncles. Carpocerite as long as lateral tooth of scaphocerite. Tooth in inferior margin of basicerite prominent, but shorter than stylocerite.

Ratio of articles of third maxilliped: 10:4:7. Last two articles bearing only moderately dense hairs, tip bearing a brush of long fine hair.

Large cheliped massive, cylindrical, 2.2 times as long as broad with fingers occupying the distal 0.3. Male chela slightly more massive than that of female. Medial, superior and upper lateral faces of palm and dactylus covered by a mat of fine, extremely long setae, each arising from a small pustule. Lateral face lightly punctate, inferior margin with grooves and bearing sparsely set fine setae. Superior margin of chela with narrow transverse groove proximal to dactylus, obliquely placed and continuing onto lateral face where it ends abruptly in the distal end of a narrow longitudinal groove on the lateral face. Groove on lateral face continues proximally to *linea impressa*. Longitudinal groove on lateral face forms a small pocket just oppostie termination of superior groove. Tip of dactylus of large chela usually truncate, but at times terminating in a small sub-acute tooth. Merus 1.5 times as long as broad, with an acute tooth sub-terminally on inferointernal margin.

Small chela 3.1 times as long as broad, palm 2.6 times longer than fingers. Inner face of palm bearing long fine setae similar to those of large chela. Carpus cup-shaped, 0.3 times as long as palm, bearing on its distal margin just proximal to superior margin of palm a strong acute tooth. Merus two times as long as broad, superior margin slightly projected as rounded tooth, inferointernal margin terminating in an acute tooth.

Carpal articles of second leg with ratio: 10:30:6:6:10.

Third leg stout. Ischium with acute spine. Merus three times as long as broad with strong acute tooth on distoinferior angle. Carpus almost half as long as merus,

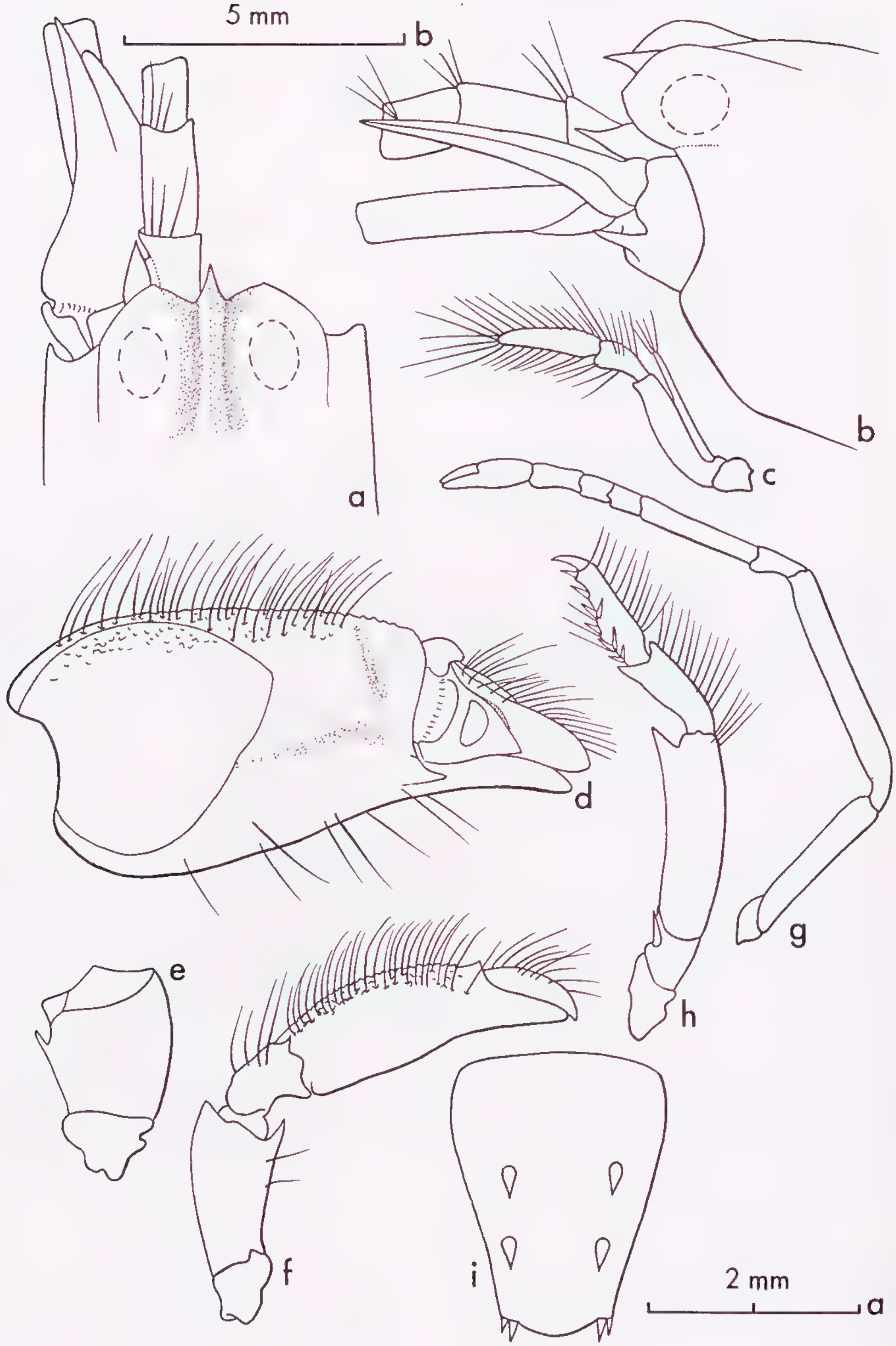

Fig. 19 *Alpehus acutofemoratus* Dana
20 mm male from BAU 55. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d.** large chela, superolateral face; **e.** merus of large cheliped, meidal face; **f.** small cheliped, medial face; **g.** second leg; **h.** third leg; **i.** telson. a, b, i scale a; c, d, e, f, g, h scale b.

distosuperior margin terminating in rounded tooth and distoinferior margin in an acute tooth. Propodus more than half as long as merus, bearing on its inferior margin 8-10 spines and a pair distally. Dactylus 0.4 as long as propodus, simple.

Telson 2.3 times as long as posterior margin is broad, first pair of heavy dorsal spines placed anterior to middle. Inner pair of posterolateral spines almost as large as dorsal spines.

DISCUSSION: Bate's specimen from Arrou Island, north of Cape York, certainly cannot be *A. acutofemoratus* since the first carpal article of the second leg is longer than the second instead of "second more than twice as long as first" (Dana, *loc. cit.*). Also in Bate's specimen (fig. 2, *loc. cit.*) the merus of the third leg is much more slender than in Dana's and it lacks the tooth at the distal end of the merus and carpus found in *A. acutofemoratus*. Finally the sculpturing of the large chela as shown by Bate (fig. 2b) is like that found in the Edwardsii Group and quite unlike that of the Sulcatus Group. Unfortunately, Bate's specimen is missing from the Challenger collection at the British Museum (Natural History) and probably is lost, and from his figures and description we cannot identify if further.

We have compared our specimens particularly with the long description and excellent figures of De Man (1902), and find they are in agreement except the lateral tooth of the basicerite in De Man's specimen is a little more prominent than in our specimens.

BIOLOGICAL NOTES: We have collected this species in Australia from heads of coral from water not deeper than 10 ft. It is apparently an intertidal species. In Indonesia we found this species living in fissures in coral similar to those made by *Alpheus deuteropus* Hilgendorf (see p. 42). Our largest specimen was 22 mm long.

AUSTRALIAN DISTRIBUTION: Torres Straits; Green Island, near Cairns; Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Indonesia; Thailand; Philippines; Marshall Islands; Samoa.

Alpheus sulcatus Kingsley

Fig. 20

Alpheus sulcatus Kingsley, 1878:193. Crosnier and Forest, 1966:237, fig. 9a-d.

Alpheus macrochirus Richters, 1880:164, pl. 17, figs. 31-33. De Man, 1902:863. Crosnier and Forest, 1965a:356, figs. 1, 2.

?*Alpheus californiensis* Holmes, 1900:186, pl. 2, fig. 42, pl. 3, figs. 43-44 (according to Crosnier and Forest, 1966).

Nec *Alpheus macrochirus* De Man, 1888a:519 (=*A. ehlersii* De Man).

Alpheus luciae Barnard, 1946:389; 1950:755, figs. 143 j-m.

SPECIMENS EXAMINED: 1 specimen from AC-S2; 1, AM 8 (AM P. 27831); 1, AM 27 (AM P. 27841); 1, AM 69 (AM P. 27842); 1, AM 71 (AM P. 27438); 2, AM 98 (AM P. 27782); 1, AM 129 (AM P. 27559); 1, AM 134 (AM P. 27825); 1, AM 238 (AM P. 27366); 2, AM 275 (AM P. 27402); 1, AM 282 (AM P. 27403); 2, AM 290 (AM P. 27363); 1, AM 299 (AM P. 27404); 2, AM 316 (AM P. 27364); 1, AM 328 (AM P. 27365); 1, AM P. 8566; 1, JC 24; 1, QM W 1296; 2, US 123593; 1, US 123594; 4, US 123595; 2, US 123596; 1, US 123597; 5, US 123598; 3, US

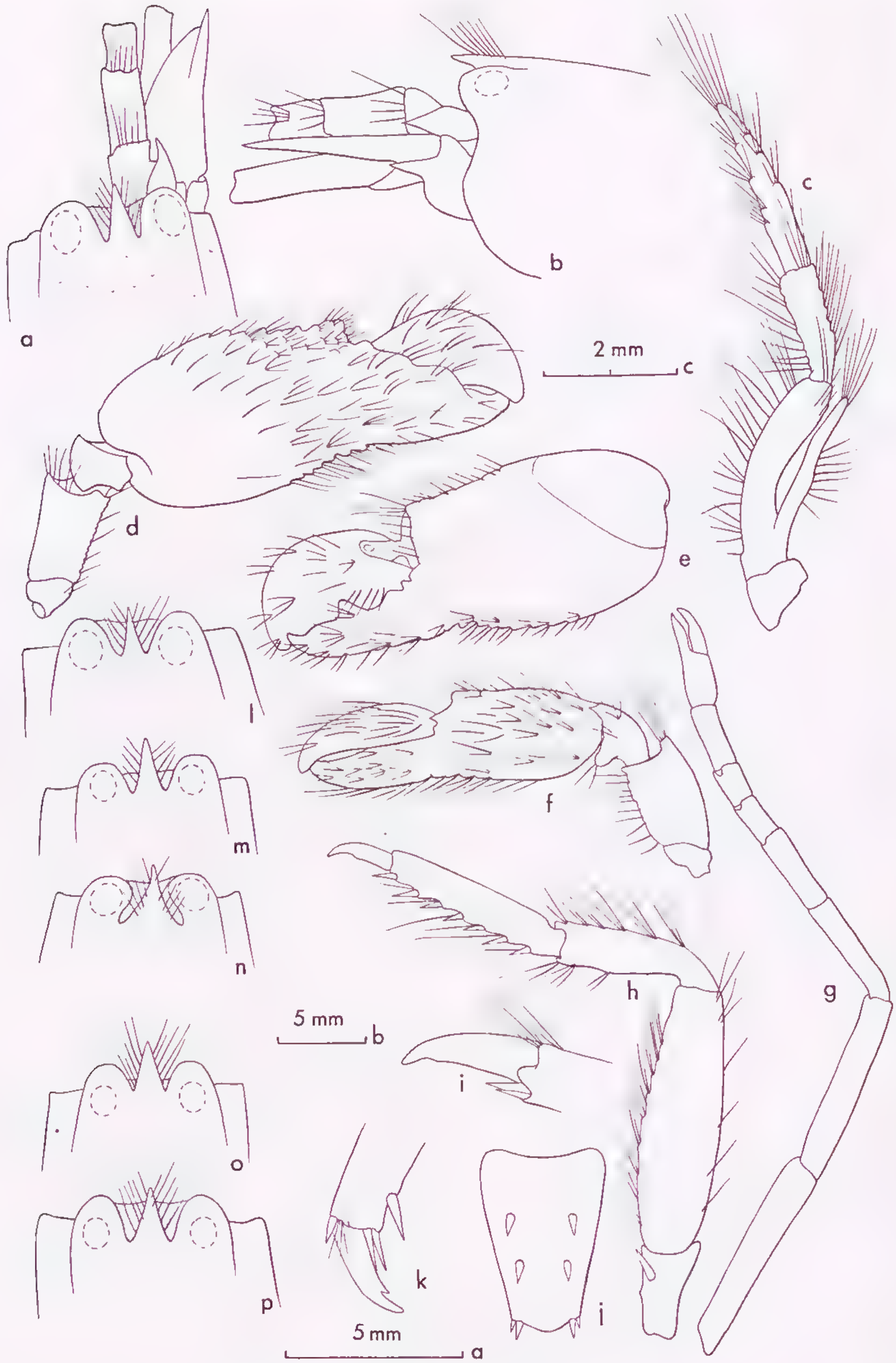

Fig. 20 *Alpheus sulcatus* Kingsley
50 mm male from WM 101-65. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d.** large cheliped, medial face; **e.** large chela, lateral face; **f.** small cheliped, medial face; **g.** second leg; **h, i.** third leg and enlarged dactylus; **j.** telson. 35 mm male from JC 24. **k.** Dactylus, third leg. Anterior region of carapace from: **l.** 40 mm male from WM 139-65; **m.** 48 mm female from AM 275; **n.** 35 mm female from US 123598; **o.** 40 mm male from AM 290; **p.** 35 mm male from WM 210-65. a, b, c, g, h, j, l, m, n, o, p scale a; d, e, f scale b; i, k scale c.

123599; 2, VM 16; 1, VM 20; 1, WM 41-65; 2, 73-65; 1, WM 101-65; 1, WM 132-65b; 1, WM 139-65; 1, WM 173-65; 1, WM 174-65; 2, WM 210-65; 3, WM 238-65; 11, WM 287-65.

DIAGNOSIS: Rostrum varying from 0.8-1.9 times as long as wide at base. Sides of rostrum bearing moderately long stiff·setae. Orbitorostral grooves deep, slightly recessed under margins of rostrum, and sharply cut off from orbital hoods. Orbital hoods slightly inflated, anterior margin rounded, without teeth. Visible part of first and third antennular article nearly equal. Second antennular article 1.5 times as long as third article and two times as long as broad. Stylocerite acute, reaching slightly past end of first antennular article. Outer margin of scaphocerite almost straight, lateral tooth reaching well past squamous portion; squamous portion as long as antennules, lateral tooth as long as carpocerite.

Ratio of articles of third maxilliped: 10:5:8. Inferior margin bearing long setae; third article bearing setae in tufts rather than rows, tip with tuft of setae two-thirds as long as article.

Large chela compressed, 2.6 times as long as broad, with fingers heavy and occupying distal third. Lateral face glabrous except along margins and bearing longitudinal groove arising near middle of palm and running to dactylar articulation; groove at mid-length may be shallow or a deep "V". Superior margin of palm with low rounded ridge arising near carpal articulation distally curving slightly to terminate above palmar adhesive plaque. Medial face with longitudinal groove similar to that of lateral face, but usually less deep; face bearing many long heavy setae in patches, those near distal portion of superior ridge arising from heavy bosses, those on other portions of face from slight indentations. Lower margin with slight constriction opposite dactylar articulation and carrying on the distal half or two-thirds of margin and lower portions of each face similar long setae, at times on bosses. Dense row of short setiferous bristles on median edge of palmar adhesive plaque. Both fingers with patches of setae, some long, some short. Dactylus heavy, distally rounded and reaching beyond pollex; plunger very heavy and curved. Merus 1.7 times as long as broad, inferointernal margin irregular and bearing short setae; superodistal angle not produced but bearing long setae. Carpus without tooth on inferodistal margin.

Small chela not sexually dimorphic, three times as long as broad with fingers slightly longer than palm. Medial side of dactylar articulation bearing sub-acute tooth. Palm in general with ridge, bosses and setae of large chela, but not as highly developed; longitudinal grooves of both faces lacking. Fingers also hirsute, at times heavily so on medial faces. Merus 1.8 times as long as broad; inferointernal margin irregularly serrate with scattered short setae; superodistal margin with long setae. Carpus with obtuse tooth projecting above superior margin of palm.

Carpal articles of second leg 10:(7-9):3:3:4.

Ischium of third leg armed with a spine. Merus 3.5 times as long as broad, without teeth, but with inferior margin bearing patches of setae. Carpus 0.6 as long as merus; superodistal margin projecting as heavy rounded tooth, inferior margin slightly projecting. Propodus 0.7 as long as merus, bearing on its inferior margin six spines, each associated with a long setae, and a pair distally. Dactylus 0.3 as long as propodus, varying from uniformly conical to bearing a definite secondary unguis (as in fig. 20k); most specimens with a thickening only at site of secondary unguis (as in fig. 20i).

Telson 2.5 times as long as posterior margin is broad. First pair of dorsal spines placed anterior to middle. Spine on outer uropod not dark.

DISCUSSION: This species was formerly known in the Indo-Pacific as *A. macrochirus* Richters (1880) although it was known to be related to *A. sulcatus* Kingsley (1878) from the Atlantic and the western coasts of America. Crosnier and Forest, using specimens from the Gulf of Guinea discussed what they believed to be three differences between the two species. We have examined our 51 specimens from Australia, 26 specimens from the Indian Ocean and 26 specimens from the southern Philippines in reference to these points of difference and have found all were variable in each of the three groups of specimens we studied. Specifically we found:

1. Crosnier and Forest believed that the orbitorostral grooves in *A. sulcatus* were broader and extended only to the posterior margin of the eyes, while in *A. macrochirus* they were narrower and extended posterior to the base of the eyes. We found that the width of the grooves was a function of the breadth of the rostrum, and that the rostrum varied from less long than broad at its base to over twice as long as broad. However, in almost all specimens in these collections the length of the grooves were more like *A. sulcatus* than the condition attributed to *A. macrochirus.*

2. Crosnier and Forest reported that the fingers of the large chela were relatively broader and longer when compared to the palm in *A. sulcatus* than in *A. macrochirus.* In 25 measured specimens from Australia we found the ratio of palm height to finger height varied from 1.2-1.8 times, and the palm varied from 1.8-2.6 times the length of the fingers. This variation extends beyond the differences given by the two authors.

3. Crosnier and Forest believed that the dactylus of the third leg was simple in *A. sulcatus* and biunguiculate in *A. macrochirus.* The specimens we examined varied from having a uniform taper from base to tip, through having a swelling of various sizes along the inferior margin, to having a definite, but variable, secondary unguis.

After this study we told Dr Forest of our conclusions and asked that he compare selected specimens from Australia, the Philippines and East Africa from our collections with his specimens from West Africa. He did and concurred with us that *A. sulcatus* is a species of possibly discontinuous circumtropical distribution.

The placement of *A. macrochirus* in synonymy will necessitate changing the name of the sub-generic group to the Sulcatus Group.

Barnard (1946:389) described a new species, *A. luciae,* from St Lucia Bay, Zululand, which he suggested was very close to *A. macrochirus;* in 1950 (fig. 143) he figured this species. Through the courtesy of Dr B. F. Kensley, of the South African Museum, we were able to examine the holotype and compared it to specimens in our collections. None of our specimens had as deep a constriction on the inferior border of the large chela opposite the articulation of the dactylus as figured by Barnard (fig. 143m), but the holotype was less constricted than figured. Barnard stated that all dactyli of the thoracic legs were simple, but upon close examination we found that the dactyli did have a slight swelling on the inferior surface similar to those of many of our specimens (see fig. 20i). Finally, Barnard believed that his specimen was a male, but he stated that the second pleopod did not have an *appendix masculina.* However, Kensley (1970:118, fig. 13) re-examined the type and found the second pleopod did have an *appendix masculina* which we were also able to confirm. In view of the variations we have found for this species, we can find no specific differences between the forms and are placing it, too, in synonymy to *A. sulcatus.*

Crosnier and Forest *(loc. cit.)* have suggested that Holmes' species *A. californiensis* may also be a synonym. We must leave this question to those working with American alpheids.

A. sulcatus, common in tropical Australian waters and penetrating to temperate waters on the west coast only to Shark Bay, has reached Grafton, N.S.W., and the waters off Victoria in the south-east. However, if one uses the following criteria there would appear to be three separate but closely-allied temperate water species:

1. A flattened triangular rostrum whose margins overhang the orbitorostral grooves;
2. Large chela of similar general configuration, with longitudinal grooves on the palm and a tendency to be hirsute;
3. Small chela of similar general configuration (but not showing any great specialisation), and also with a tendency to be hirsute;
4. A tendency to have a biunguiculate dactylus on the third leg.

Sharing these characteristics with *A. sulcatus* are *A. australosulcatus sp. nov., A. parasocialis sp. nov.*, and *A. socialis Heller.* Each is differentiated from *A. sulcatus* and from each other by rather firm characteristics that have not been observed to overlap, and which are presented in Table 1, p. 86.

We suggest that in the successful adaptation from a restricted tropical ecological niche to the changed ecosystems in the colder waters, different new niches were found, resulting in the morphological differences listed in the table. As the morphological differences are maintained in spite of ranges that overlap or come close to overlapping in all four species, they must represent distinct stocks with genetic separation, or true species, not sub-species.

BIOLOGICAL NOTES: This species has been collected under rocks intertidally and from corals taken from shallow water. It has been dredged from as deep as 13 fathoms. Moulton (1967:7) reported a possible commensal relationship at Heron Island. "Four pairs of shrimp were collected and each pair was hovering over one of the worms *(Eurythoe complanata)* beneath a coral bombie on Heron Island Reef". Yaldwyn has supplied the following colour notes for two specimens from One Tree Island (AM316): "Uniform dark green with mottling on hands". We have specimens up to 58 mm in length.

AUSTRALIAN DISTRIBUTION: On the west coast from Rottnest near Perth to Cape Leveque, the east coast from the Coral Sea to near Sydney, N.S.W. Three specimens came from Victoria.

GENERAL DISTRIBUTION: As *A. sulcatus* the species has been reported in the eastern Pacific from the Galapagos Islands to Panama and Peru (and possibly California), and from the eastern Atlantic off Africa. In the Indo-Pacific it has been reported, mostly as *A. macrochirus*, from east and south Africa across to the Society Islands. We have specimens in our collections from the Red Sea. Strangely, it has not been reported from Japan, Hawaii or the Caribbean.

Alpheus australosulcatus sp. nov.

Fig. 21

HOLOTYPE (AND ONLY SPECIMEN): 65 mm female from North Head, Flinders, Victoris *(sic)*. Collected by F. E. Grant 30/12/00. Dredged. (AM P. 13551).

DESCRIPTION: Rostrum flat, triangular, 1.3 times as long as broad at base, reaching

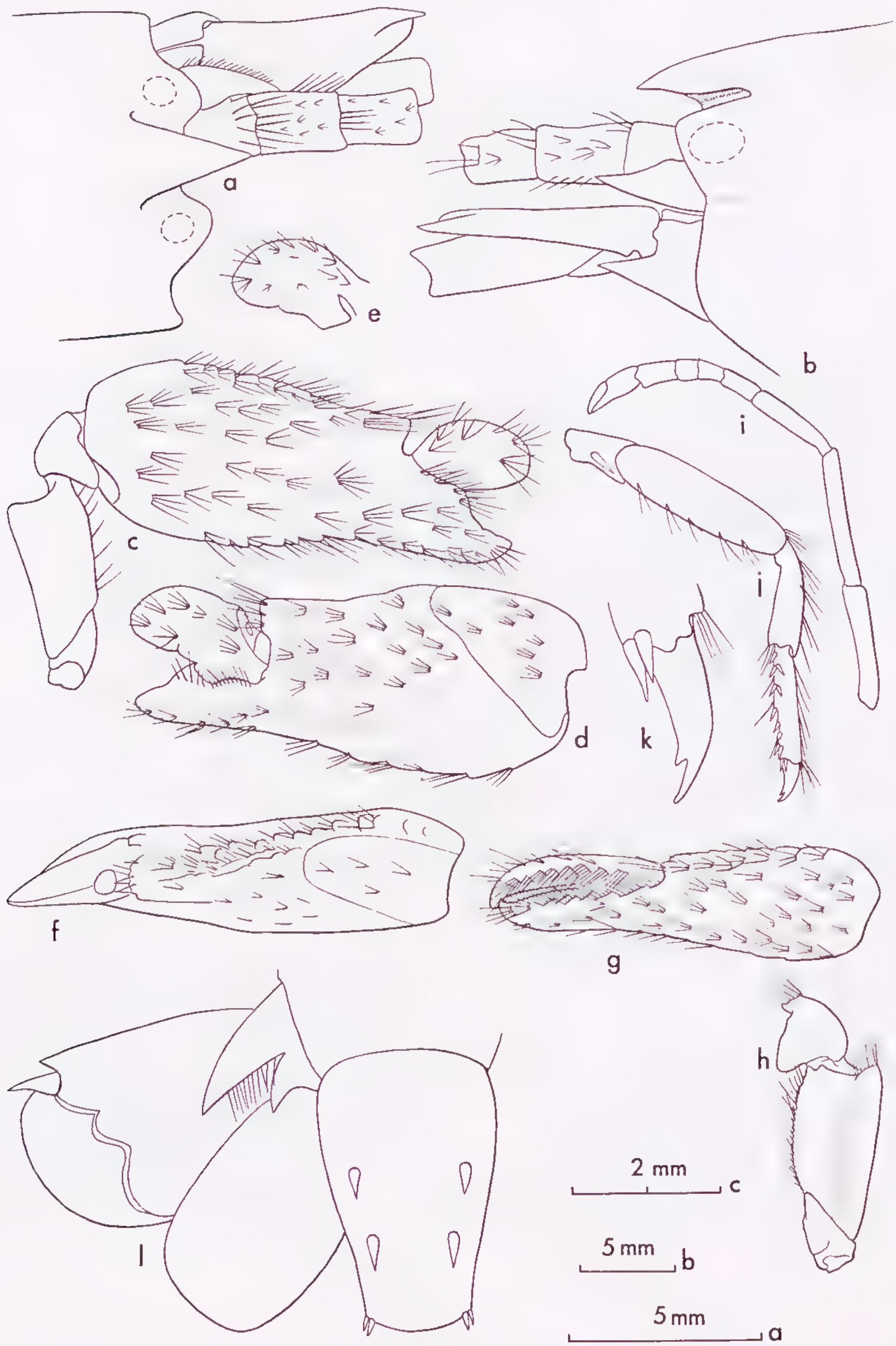

Fig. 21 *Alpheus australosulcatus* sp. nov.
Holotype (female). **a, b.** Anterior region, dorsal and lateral view; **c.** large cheliped, medial face; **d, e.** large chela and dactylus lateral face; **f.** large chela, superior face; **g, h.** small chela and merus, medial face; **i.** second leg; **j, k.** third leg and enlarged dactylus; **l.** telson and uropods. a, b, k scale a; c, d, e, f, g, h, i, l scale b; j scale c.

to end of first antennular article. Orbitorostral grooves deep, recessed under rounded lateral margins of rostrum. Orbital hoods not inflated, not bearing teeth on orbitorostral margin but projected into arcuate prominences. Orbitorostral margin of carapace deeply concave towards base of rostrum. Antennular articles nearly equal, second article 1.4 times as long as broad; distal margins of first and second article bearing many forward-directed setae. Stylocerite acute, reaching near middle of second antennular article. Outer margin of scaphocerite nearly straight, lateral tooth reaching well beyond antennular article, tip directed inward, squamous portion narrow, a little shorter than lateral tooth. Carpocerite stout, sub-equal in length to tooth of scaphocerite. Basicerite with tooth on inferior margin broad at base and reaching almost as far forward as stylocerite.

Third maxilliped similar to that of *A. sulcatus,* reaching well beyond antennules. Ratio of articles: 10:1.4:0.7.

Large chela compressed, 2.5 times as long as broad, fingers occupying distal 0.2. All surfaces of chela, including fingers, bearing patches of stiff setae arising from the distal edges of slits in the integument, often arranged in more or less lineal series; patches of setae on superior margin emerging from bosses, outer face bearing two rounded and shallow longitudinal grooves, the inferior arising below socket on pollex and extending to middle of palm, the superior, broader and shallower than inferior, arising proximal to dactylar articulation and terminating distal to inferior groove. Tip of dactylus heavily rounded, tip of pollex acute. Merus 2 times as long as broad, distal margins not projecting. Tooth on inferodistal margin of carpus not projecting.

Small chela 3.4 times as long as broad, finger a little shorter than palm. All surfaces of palm with setae in patches similar to that of large chela. Patches of setae on lateral face of minimal development. Medial and lateral side of both fingers near oppositional faces carrying short stiff setae arranged in oblique combs which cross to make regular intermeshing brushes. Superodistal margin of carpus bearing prominent sub-acute tooth.

Carpal articles of second leg with ratio: 10:4:3:3:4.

Ischium of third leg bearing spine. Merus inermous, four times as long as broad, bearing along inferior margin several tufts of setae. Carpus 0.5 as long as merus, superodistal margin slightly projected. Propodus 0.6 as long as merus, bearing on its inferior margin 10 spines with a pair distally. Dactylus 0.3 as long as propodus, biunguiculate with small inferior tooth.

Telson three times as long as posterior margin is broad, anterior pair of dorsal spines placed anterior to midline. Articulation of outer uropod with scalloped pattern.

DISCUSSION: This species is plainly within the Sulcatus Group, and is remarkably close to *A. sulcatus* itself. Its separation from *A. sulcatus* and those species we believe to be related to *A. sulcatus* in temperate Australian waters is given in Table 1; in summary, this species differs from *A. sulcatus* in the form of the rostrum and its lack of setae, the length of the scaphocerite and the brushes placed in series on the fingers of the small chela. It is the condition of the small chela upon which we place the greatest reliance.

As indicated under the discussion of *A. sulcatus* above, this sole specimen was collected not too far away from the three specimens of *A. sulcatus* taken in waters off Victoria, and *A. parasocialis* B&B, also related, has been taken in New South Wales, Tasmania and South Australia, so the ranges of these species overlap. Only *A. socialis* of the group does not penetrate so far south.

TABLE 1
Differences between *A. sulcatus* and its southern Australian derivatives

	I *A. sulcatus* Kingsley	II *A. australosulcatus* B&B	III *A. parasocialis* B&B	IV *A. socialis* Heller
Rostrum	Broad triangle cut off from orbital grooves but usually not overhanging; with setae on margins	Broad triangle overhanging grooves, without setae	Narrow triangle, overhanging grooves; without setae	Same as III
Orbital hoods	Without teeth	Same as I	With small teeth	Same as III
Stylocerite	To near end of 1 ap.*	To middle of 2 ap.	Same as I	Same as I
Squame	To near end of 3 ap.	Same as I	To near end of 2 ap.	Same as III
Tooth on inferior margin of basicerite	Heavy, to first quarter of 2 ap.	Heavy, to middle of 2 ap.	Slender, past middle of 2 ap.	Same as III
Third maxilliped second article	Margins parallel	Same as I	Slight distal broadening	Inferodistal margin projecting as heavy lobe
third article	With marked distal taper	Same as I	With slight distal taper	With strong taper
Large chela	Moderately setiferous	Heavily setiferous	Slightly setiferous	Same as III
Carpus, large cheliped	Distally inermous	Same as I	With inferodistal tooth	Same as I
Fingers, small chela	With light, random setae	With heavy setae in brush	With light setae	With setae in row
Third leg, merus	Unarmed	Unarmed	Usually with distal tooth	Unarmed
dactylus	From simple to biunguiculate	Biunguiculate	Biunguiculate	Biunguiculate

* 1, 2, 3 ap. = first to third articles of antennular peduncles.

The name indicates that we believe this to be a southern form of *A. sulcatus*. The holotype will be deposited in the Australian Museum.

BIOLOGICAL NOTES: All of the data we have is that listed above from the label in the vial. It is noteworthy that in all of the collections from New South Wales and Victoria no further specimens have been found.

Obesomanus Group

Rostrum reduced, at times lacking. Species with a tendency to develop elongate antennual peduncles, tooth on stylocerite reduced or lacking, reduced scaphocerite and carpocerite. Large chela usually proximally rounded, tapering distally with moderate to slight longitudinal grooves; dactylus of the form of a single to double-headed hammer, closing over end of pollex (*A. perplexus* Banner only with marked longitudinal grooves like those found in Macrocheles Group). Small chela never balaeniceps. Second legs at times extremely long and of asymmetrical development. Third legs variable but usually not heavily armed. Outer uropods may lack articulation. Telson variable, at times narrow at tip, may lack anal tubercles. At times with strong sexual dimorphism.

Some, and perhaps most, species live in protected galleries in the crust of coralline algae.

DISCUSSION: We reviewed the Obesomanus Group in 1966a (p. 162), and of the 18 previously reported species or unnamed forms, we accepted 10, one of which was new, and placed eight in synonymy. In Australia we have found only two species, *A. obesomanus* Dana and *A. malleodigitus* (Bate); *A. microstylus* (Bate) must be included, however, as its type locality is the Torres Straits. In our collections consisting of a total of 186 specimens of these three species from the central Pacific we found considerable variation in characteristics previously used for the separation of these species which we analysed in detail in our 1966 study; we found the variations repeated in our Thai collections (1966b:99). As similar variations were noted in the Australian collections, we here summarise the findings for an aid to Australian workers:

ROSTRUM AND ORBITAL HOODS: The rostrum is small and variable and it may be lacking; orbitorostral margin may be straight or somewhat indented towards rostral base.

ANTENNULAR PEDUNCLES: The second article in *A. malleodigitus* ranges from 1.3 to 4.9 times the length of the first article, and from 2.5 to 6.7 times as long as broad; the ranges of the other two species are less broad, but are largely overlapped by the range of *A. malleodigitus*. The presence of a tooth on the stylocerite is variable, at least in *A. microstylus*.

ANTENNAL PEDUNCLES: The relative lengths of the lateral tooth and squame of the scaphocerite and the carpocerite are variable, but still offer one of the sure points to differentiate between the three species. In *A. malleodigitus* the tooth of the scaphocerite ranges in length, reaching from the beginning to the end of the second antennular article, and the carpocerite to about its middle, while in *A. obesomanus* and *A. microstylus* both articles reach to near the end of the third article. The latter two species may be distinguished, however, by the squamous portion which reaches only near to the middle of the second article in *A. obesomanus* (as well as *A. malleodigitus*), and to near the end of the third article in *A. microstylus*. In other words, the scaphocerite and carpocerite are normal in *A. microstylus*, the squame alone is reduced in *A. obesomanus*, and both the scaphocerite and carpocerite are reduced in *A. malleodigitus*.

LARGE CHELA: As this is largely made of relatively soft chitin, grooves and ridges may

appear, or normally occurring ones may be intensified, as artifacts arising out of preservation.

SMALL CHELA: The range of variation of the ratios between palm and finger length in *A. malleodigitus* is from 2.4 to 3.7, and completely overlaps the ranges found in the other two species. There is no sexual differentiation.

SECOND LEGS: The second article ranges from about 1.0 to 2.0 times the length of the first in *A. malleodigitus* and from 2.0 to 4.6 times the length in *A. obesomanus;* the few specimens we had of *A. microstylus* ranged from 1.9 to 3.3.

THIRD LEGS: In *A. malleodigitus* the length/breadth ratios of the merus and carpus, with both ranging from about three to seven times as long as broad, almost completely overlap the ranges of the other two species.

TELSON: Here *A. obesomanus* had the greatest range of length to breadth at the tip, with ratios running from 2.5 to 7.0, encompassing the ranges of the other two species; however, usually the tip of the telson in *A. obesomanus* is narrow and straight with the inner spines of the posterolateral pair long, heavy and located close to middle, while in the other two species it is broader, somewhat convex and with spines of more normal size and position.

The three species live in similar habitats, as we described from Thai waters (B&B, 1966b:101): "[They live] in branching galleries under coralline encrusting algae on heads of dead coral, usually in regions of wave action. The galleries communicate to the surrounding water by a series of uniform and often regularly placed holes or ports, each too small to permit the egress of the shrimp. In each set of galleries lives a single pair of shrimp, and each set is separated from the galleries of neighbouring pairs. Of the pair within the burrow, the female is usually the larger and softer, with smaller chelae. No differences in habitat could be detected for the three species; indeed, on the western beaches of Phuket, all three species were taken from galleries on a single coral head." However, Dr A. J. Bruce, of the Heron Island laboratory, has collected some *A. obesomanus* from living coral of the genus *Acropora* where they occur in deep burrows, and "I have also seen them in small fossa in other corals, usually only in pairs." (Personal communication).

Of the 27 collections that we personally made of the two species along the Great Barrier Reef complex from Thursday Island to Heron Island, 10 contained both species, 12 contained *A. malleodigitus* alone, and five contained *A. obesomanus* alone. Unlike the central Pacific and Thai collections where the two species were collected in roughly equal numbers, in the Australian collections were over 200 specimens of *A. obesomanus* and only 32 of *A. malleodigitus.* In our earlier collections *A. microstylus* was by far the most uncommon and in Australia is only known from Bate's type as mentioned above.

Coutiére, in giving biological notes from his observations at Djibouti (1898i:198) remarked on *A. malleodigitus* that it was found always in galleries in the *"croûte"* of the reef that had been previously dug by burrowing annelids or molluscs, that the male sat in the entrance to the burrow to protect it. He also stated: *"Un détail assez singulier est la présence dans leur retraite d'un paquet d'Ulves vertes, vraisemblablement apporté par l'animal, soit comme une réserve alimentaire, soit pour utiliser le dégagement d'oxygène dont l'Ulves est le siège et qui s'y continue encore quelque temps après qu'elle a été soustraite aux radiations lumineuses".* Except for the presence of the species in galleries, his other observations we have not been able to confirm. Both species are, as Coutière described for *A. malleodigitus,* of sulphur yellow colour, with the ovary green through the transparent carapace in the female.

We should add that we still have doubts about the separation of these three species. In the large number we have examined the separation of them on morphological characteristics seems certain in spite of their wide variations, and in co-habiting pairs that we have separately bottled we have never had any examples of two different species living together. On the other hand, they do occupy what appear to be identical galleries in the same habitat and in the same ecological zones, and presumably their ways of life are also identical. It is seldom that two distinct species of apparently similar ecological requirements can continue to co-exist in the same habitats. It should be noted, however, that *A. obesomanus* has not been collected west of the Torres Straits, but that *A. malleodigitus* extends to Dampier Archipelago in Western Australia.

We are also rather surprised that more species of the Obesomanus Group have not been found in Australian waters; while the other species are never common in our previous collections from coral reefs, they do appear. Should other species be found in Australia, we refer the worker to the key in our publication (1966a:173). We also caution future workers about the difference in opinion on the validity of the genus *Thunor*, for while we placed it into synonymy in the 1966 study, Chace in 1972 (p. 105) revived the generic name for the Caribbean species *T. rathbunae* (Schmitt).

In the following three species we describe only the most abundant *A. obesomanus*, for except for small differences (listed above) the three species are essentially the same; we illustrate these differences in Figure 22.

Alpheus obesomanus Dana

Fig. 22a-l

Alpheus obesomanus Dana, 1852:547, pl. 34, fig. 7. Boone, 1935:135, pl. 35. Banner and Banner, 1966a:168, figs. 8-18; 1966b:101, fig. 35.

Alpheus lutini Coutière, 1905a:885, fig. 24.

Alpheus species #2. Banner, 1956:351, fig. 15.

Nec *Alpheus obesomanus* Pocock, 1890:520 (=*A. cristulifrons* Rathbun according to Schmitt, 1924:65).

Previous Australian record: Miers, 1884:287. Port Molle, Qld.

SPECIMENS EXAMINED: 1 specimen from AM 52 (AM P. 27513); 1, AM 74 (AM P. 27500); 2, AM 109 (AM P. 27510); 2, AM 174 (AM P. 27524); 3, AM 196 (AM P. 27323); 1, AM 238 (AM P. 27324); 1, AM P. 13584; 2, BAU 14; 2, BAU 15; 15, BAU 17; 2, BAU 18; 1, BAU 20; 20, BAU 21; 6, BAU 23; 6, BAU 25; 2, BAU 27; 39, BAU 30; 16, BAU 31; 58, BAU 32; 10, BAU 33; 2, BAU 37; 3, BAU 43; 4, BAU 47; 4, BAU 48; 2, BAU 50; 9, BAU 52; 9, BAU 55; 8, BAU 57; 6, BAU 58; 2, 75 LIZ-8 (AM P. 27910); 3, 75 LIZ-O (AM P. 27915); 3, 75 LIZ-Q (AM P. 28148); 2, 75 LIZ-R (AM P. 27917); 5, 75 LIZ-S (AM P. 27911); 3, 75 LIZ-V (AM P. 27912).

DIAGNOSIS: Rostrum short, triangular, at times vestigial, never reaching beyond first quarter of visible part of first antennular article. Rostral carina slight, continued posteriorly to base of eyes. Orbital hoods slightly inflated, forming shallow orbitorostral grooves, frontal margin gradually rounded.

Second antennular article varying from 1.5-3.0 times as long as wide. Visible part of first antennular article and third article sub-equal in length, about 0.3-0.7 times as long as second. Stylocerite without tooth, reaching only to middle of visible part of first antennular article. Scaphocerite with strong lateral tooth which reaches to near end of

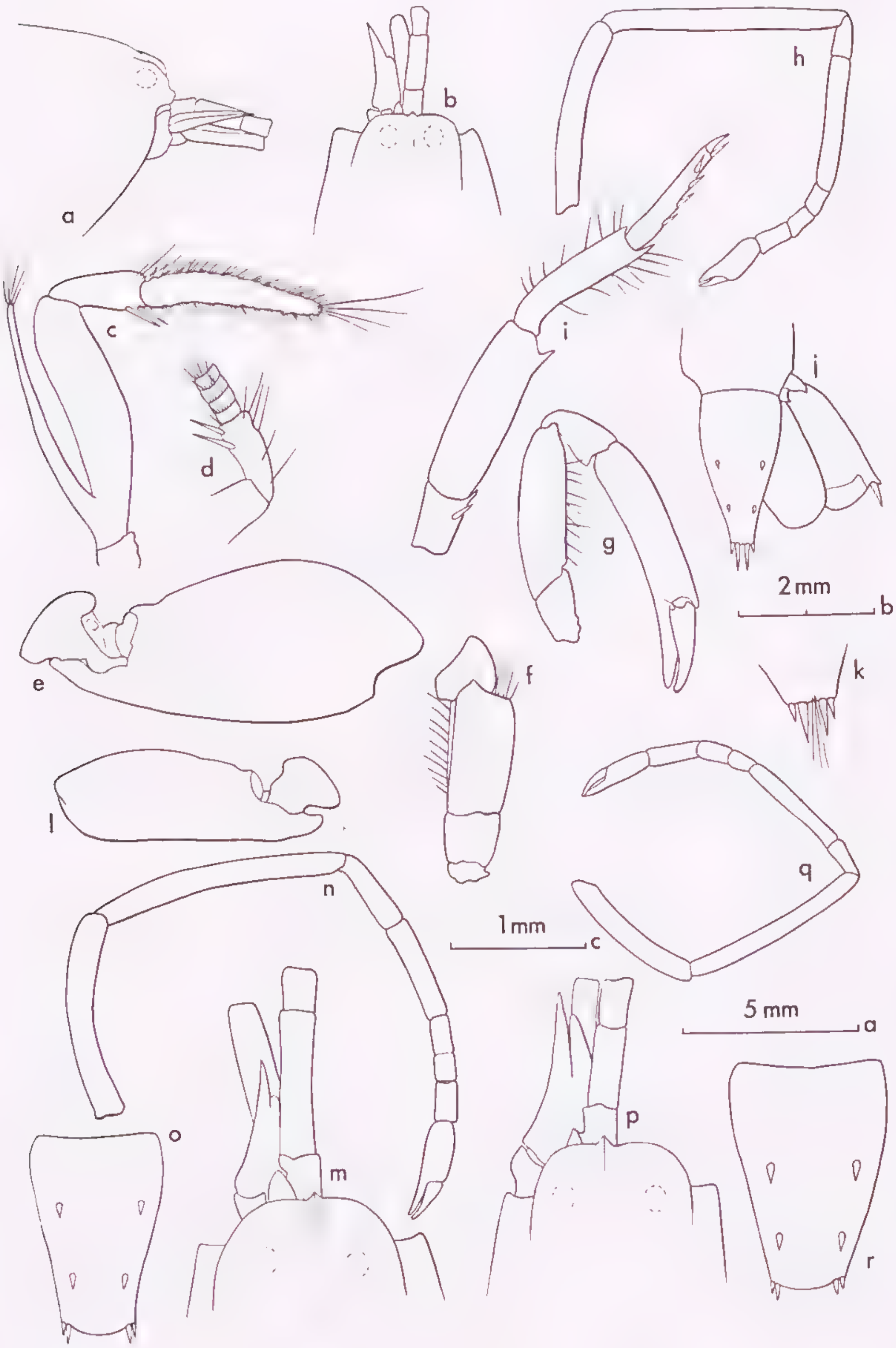

Fig. 22 Species of the *Obesomanus* Group
Alpheus obesomanus Dana, 17 mm male from BAU 17. **a, b.** Anterior region, lateral and dorsal view; **c, d.** third maxilliped, lateral face and detail of second article, medial face; **e, f.** large chela and merus, lateral face; **g.** small cheliped, lateral face; **h.** second leg; **i.** third leg; **j, k.** telson and uropods and detail of posterior end of telson. 15 mm male from BAU 33. **l.** Aberrant large chela. *Alpheus malleodigitus* (Bate) 21 mm male from BAU 20. **m.** Anterior region dorsal view; **n.** second leg; **o.** telson. *Alpheus microstylus* (Bate) 25 mm male from the Red Sea. **p.** Anterior region, dorsal view; **q.** second leg; **r.** telson. c, d, h, i, k scale a; a, b, e, f, g, j, l, n, o, p, r scale b; m, q scale c.

antennular peduncle, squamous portion reduced, reaching to near middle of second antennular article, and usually without setae but at times bearing short fine hairs. Carpocerite slender, usually as long as antennular peduncle; basicerite without lateral tooth.

Articles of third maxilliped with ratio: 10:3:6. Distal end of internal margin of second article bearing one or two stiff setae and fine hairs; superodistal margin bearing strong setae, but not as heavy as those on the inferior margin. Lateral margins of third article bearing a series of patches of short setae, with a brush of long hairs distally.

Large chela oval in section proximally, tapering towards fingers. Dactylus in form of double-headed hammer with both heads heavy and rounded; dactylus closing over and beyond short, and somewhat excavated, pollex. Pollex bearing tufts of short, stiff bristles on either side. Dactylar articulation broad, dactylar and palmar adhesive plaques large; palmar plaque surrounded by heavy ridge of chitin around circumference except on inferior portion. Palm always with marked depression proximal to articulation to accommodate head of dactylus when flexed. Depression extending proximally a short distance on superior margin, into a variable depression on medial face, and terminating laterally near adhesive plaque. Lateral face of palm with rounded depression below dactylar articulation, extending distally to middle of pollex, proximally a similar distance. Inferodistal surface of palm and pollex somewhat flattened. Merus without teeth, twice as long as broad.

Small chela without sexual differences, varying from about 3.5 to 5.0 times as long as broad, palm cylindrical without sculpture, and from about 2.5 to 4.0 times length of fingers. Merus of variable proportions, unarmed.

Second legs asymmetrical in length in both sexes, with the longer about 1.5 times the length of shorter, and with meral length of longer approximating length of carapace. Ratio of carpal articles of both legs variable, centering on 10:30:7:7:13, but with the second article varying from about 2.0 to 4.5 times length of first.

Ischium of third leg with spine. Merus 3.6 times as long as broad with strong tooth on distal end of inferior margin. Carpus without spines, but bearing hairs on its inferior and superior margin; inferodistal margin with a strong acute tooth; superodistal margin also with acute tooth, but much smaller than inferior. Propodus a little shorter than carpus and bearing on inferior margin four spines and a pair distally. Dactylus simple, 0.2 as long as propodus.

Telson slender, 2.5 to 7.0 times as long as posterior margin is broad. Posterior margin straight, posterolateral pairs of spines not as near corner as usual, but with medial pair usually heavy and closer to midline. Dorsal spines extremely small and some may be lacking.

DISCUSSION: The variability of this species and its separation from related species is discussed under the Obesomanus Group.

Not previously remarked upon in the literature are the heavy setae on the inferodistal margin of the second article of the third maxilliped; these are also found in *A. malleodigitus* and *A.microstylus*.

We have figured the large chela (fig. 22l) of a specimen from Opal Reef (BAU 33) in which the superior "head" of the dactylus was somewhat reduced and the sculpturing on the chela was limited to a slight depression immediately behind the dactylar articulation; one of similar development was found in the Philippine collections. We regard this as an extension of the variation already discussed in our 1966a study.

AUSTRALIAN DISTRIBUTION: Specimens in the present collections are limited to the area from the Torres Straits to the Capricorn Group.

GENERAL DISTRIBUTION: From the Red Sea and Madagascar to the Society Islands, including Japan. It has not been reported from Hawaii.

Alpheus malleodigitus (Bate)

Fig. 22m-o

Betaeus malleodigitus Bate, 1888:565, pl. 101, fig. 5.

Alpheus malleodigitus De Man, 1902:866. Banner and Banner, 1966a: 162 *et seq.*, figs. 8-18; 1966b:103, fig. 35.

Alpheus malleodigitus var. gracilicarpus De Man, 1909a:99.

Alpheus phyrgianus Coutière, 1905a:886, fig. 25.

Alpheus persicus Nobili, 1906a:33.

Previous Australian records: Coutière, 1900:413. Murray Is., Torres Straits. McNeill, 1968:15. N. Queensland.

SPECIMENS EXAMINED: 2 specimens from AM 170 (AM P. 27526); 1, AM 305 (AM P. 27779); 2, BAU 15; 2, BAU 20; 2, BAU 21; 2, BAU 23; 4, BAU 27; 1, BAU 29; 2, BAU 30; 2, BAU 32; 1, BAU 44; 4, BAU 47; 1, BAU 48; 1, BAU 52; 1, BAU 53; 1, BAU 54; 1, BAU 56; 1, WM 26-65; 1, WM 70-65; 1, WM 247-65; 1, 75 LIZ-R (AM P. 27916).

DISCUSSION: This species is variable but is very similar in appearance to *A. obesomanus* Dana and *A. microstylus* (Bate); variation and separation of the three species is discussed above. We noted that in a pair of specimens we collected from Opal Reef, the female was an "off pinkish-red" and the male was tan.

We have examined the holotype at the British Museum (Natural History) and find it agrees with the specimens we have been identifying under this name.

AUSTRALIAN DISTRIBUTION: We have specimens in Western Australia from the Dampier Archipelago to Cockatoo Island in Yampi Sound; in the north from the Torres Straits; and on the east coast from off Cooktown to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: The Red Sea; Indonesia and Japan and across the Pacific to the Society Islands. It has not been reported from Hawaii.

Alpheus microstylus (Bate)

Fig. 22p-r

Betaeus microstylus Bate, 1888:566, pl. 101, fig. 6.

Alpheus microstylus Coutière, 1905a:884, fig. 23. Banner and Banner, 1966b:105, fig. 35.

Alpheus obesomanus De Man, 1888a:520; 1902:867 (*nec* Dana, 1852).

Alpheus malleodigitus Coutière, 1899:223, 316, figs. 270-272, 400 (*nec A. malleodigitus* (Bate)).

Alpheus microstylus var. De Man, 1911:345, fig. 68.

Previous Australian records: Bate, *(loc. cit.)*. Cape York, Qld.

DISCUSSION: As in the case of *A. malleodigitus* (Bate), this species is so similar to *A. obesomanus* Dana that we are using that species as a generalised description, and have pointed out its variation and differences from the other two species in the introduction to the Obesomanus Group. We have examined Bate's type at the British Museum (Natural History) and found it lacking all thoracic legs except for one, possibly the third. However, its anterior region with appendages and its telson confirm our identification of this species reported from previous collections. The drawings in Figure 22p, q, r were made from a specimen from the Red Sea.

AUSTRALIAN DISTRIBUTION: The only specimen known is Bate's from Cape York.

GENERAL DISTRIBUTION: This species has been reported from the Red Sea, Madagascar, Seychelles, Maldives and Laccadives, the Indian Ocean coast of the Malayo-Thai peninsula, Indonesia, Vietnam, the Marianas and Samoa. It has not been found in the eastern archipelagoes of the Pacific.

CRINITUS GROUP

Orbital teeth lacking; rostrum often reduced, at times absent. Large chela rounded in section, without grooves or ridges. Small chela of male often balaeniceps. Third legs with merus usually armed, dactylus simple or biunguiculate.

Many species of this group live in algal tubes or in sponges; other species may have similar cryptic habitats, but these have not been noted.

SPECIES FOUND IN FABRICATED TUBES

Five species of the Crinitus Group have been reported as occurring in tubes — at times branching and with embayments or chambers — which they have constructed for themselves of filamentous algae and other materials (see B&B, 1968:284-286). These are: *A bucephalus* Coutière, which may use pure algae, or algae with sponges and other materials; *A. brevipes* Stimpson, which has been found in a tube of red filamentous alga; *A. clypeatus* Coutière, which prefers a tube of red filamentous alga *(Acrochaetium)* but may use other reds, browns and blue-greens as well (Bowers, 1970:77); *A. pachychirus* Stimpson and *A. frontalis* Milne-Edwards, which in the field seem to confine their tube-dwelling activities largely to filamentous blue-green algae such as *Microcoleus spp.* (note: the names of the blue-greens referred to in the older literature are in question since the publication of Drouet (1968) which revised most of the names applied in the group). *A. brevipes* and *A. clypeatus* are not known to occur in Australian waters.

The only species known to be an obligate tube-builder is *A. frontalis* which makes massive and conspicuous tubes, up to 40 cm long and 15-20 mm in diameter (Fishelson, 1966:98). It is likely that *A. pachychirus* and *A. clypeatus* also always dwell in tubes, but as these tubes are smaller and found between fronds of dead racemous coral where they are disrupted when the coral head is broken up, the shrimp often appear in the rubble as if they were living freely in the head. The two less specialized species (see below), *A. bucephalus* and *A. brevipes,* both relatively small, have been reported as tube dwellers only once in the literature (B&B *loc. cit.*).

The five species are similar in general form and are variable in many characteristics (see B&B *loc. cit.*, and for *A. brevipes* and *A. clypeatus,* Banner, 1953:103, 107). In many characteristics the species overlap — thus the rostral fronts cannot be used to separate *A. brevipes, A. clypeatus* and *A. pachychirus,* and the

TABLE 2
Separation of the tube dwelling species of the Cinitus group

Characteristic	*A. brevipes*	*A. bucephalus*	*A. clypeatus*	*A. pachychirus*	*A. frontalis*
Front of carapace	Somewhat truncate, with slight rostral projection	Indented with definite rostrum	From slightly indented to truncate, slight projection	Similar to *A. clypeatus*	Markedly projecting, rounded truncate, with slight rostral projection.
Third article of third maxillipeds	Or normal shape, tapering, with slight short setae	Similar to *A. brevipes*	Slightly broadened with long setae in moderate numbers	Markedly broadened with heavy growth of long setae	Extremely broadened with heaviest growth of long setae.
Tooth on merus of large cheliped	Absent	Usually present	Usually present	Absent	Absent
Small chela sexually dimorphic	No	Yes	Yes	Yes	Yes
Dactylus, small chela, male	Conical, 2-3 times as long as broad; setae scattered	Subspatulate, 2.5 times as long as broad; margins lined with setiferous bristles	Subspalulate, 2 times as long as broad; margins like *A. bucephalus*	Subspatulate, 1.5 times as long as broad; margins like *A. bucephalus*	Subspatulate, 2 times as long as broad; margins like *A. bucephalus*
Ratio of first two articles of second legs	10:14-21	10:20-30	10:9-13	10:5-7	10:3-5
Tooth on merus, third legs	Present	Present	Present	Present	Absent

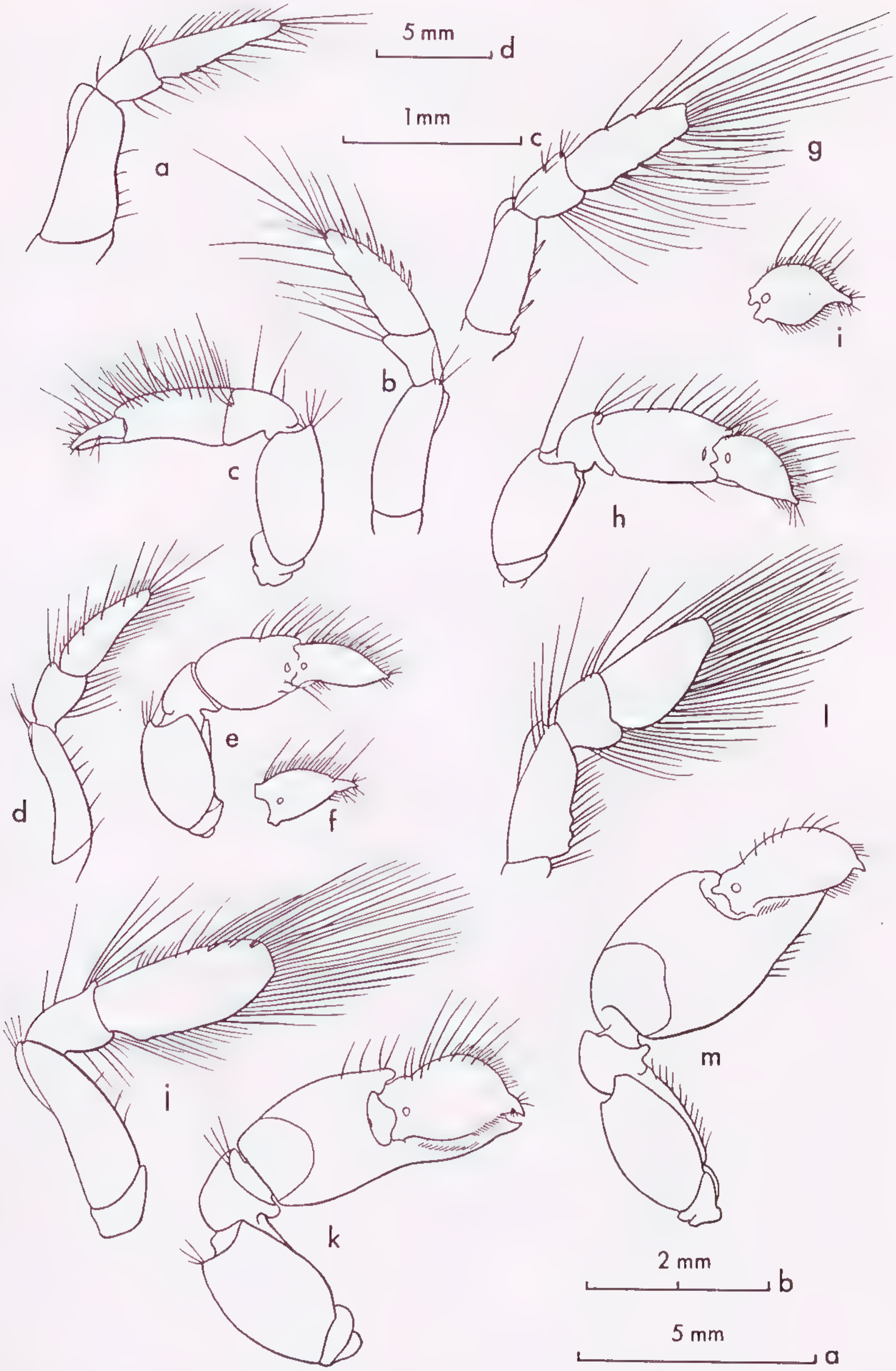

Fig. 23. Tube-dwelling species of the Crinitus Group, third maxillipeds and small chelae in lateral aspect (measurements indicate carapace lengths). *Alpheus brevipes* Dana 4.0 mm female and 3.2 mm male from City of Refuge, Hawaii: **a.** Third maxilliped, female; **b.** third maxilliped, male; **c.** small cheliped, lateral view, male. *Alpheus bucephalus* Coutiére, 5 mm male from BAU 28: **d.** Third maxilliped; **e, f.** small cheliped; dactylus held flat. *Alpheus clypeatus* Coutiére 5 mm male from Makena, Hawaii: **g.** Third maxilliped; **h, i.** small cheliped; dactylus held flat. *Alpheus pachychirus* Stimpson. 6.5 mm male from AM P. 7521: **j.** Third maxilliped; **k.** small cheliped; dactylus held flat. *Alpheus frontalis* Milne-Edwards. 12 mm male from AM P. 13572: **l.** Third maxilliped; **m.** small cheliped, lateral view (see also fig. 25 d-j). e, f, h, i, k, l scale a; c, d, g, j scale b; a, b scale c; m scale d.

ratio of the first two carpal articles of the second legs probably would present a continuum if enough specimens were measured from *A. bucephalus* which may have a ratio of 10:30 to *A. frontalis* with a ratio of 10:4. In this last characteristic, however, the frequency curve would have 5 modes and only the fringes of the individual curves would overlap.

The separation of the species is given in Table 2 and the important small chelae of the males and the third maxillipeds, not previously contrasted in the literature, are shown in Figure 23. The species appear to show a progressive adaptation for tube dwelling especially in these chelae and maxillipeds, from *A. brevipes* with "usual" small chelae and maxillipeds to *A. frontalis* with highly hirsute maxillipeds and fingers of the chelae. Other features may also reflect modification for tube dwelling — for example, the rounded rostral front, so conspicuous in *A. frontalis,* but to a degree developed in all species except *A. bucephalus,* may be an adaptation for the avoidance of entaglement in the algal filaments.

Tube building activities have been described by Cowles for *A. pachychirus* in the Philippines (1913:121), by Fishelson for *A. frontalis* in the Red Sea (*loc. cit.*) and by Bowers for *A. clypeatus* in Hawaii (1970:74). (We do not know why Fishelson believed that Cowles worked on *A. frontalis* rather than *A. pachychirus* as he reported, for we have collected *A. pachychirus* in tubes of bluegreen alga from the Philippines). It is only rarely that the shrimp do not occur in cohabiting heterosexual pairs in the tubes, and probably never as homosexual pairs or trios (see Bowers on agonistic behaviour). The tubes establish for the pair a discrete territory that is easily defensible (Bowers) and the alga of their walls is eaten (Fishelson, Bowers) although they may use other food as well (Fishelson). Bowers found that five of the seven species of algae used by *A. clypeatus* for tube building are eaten by herbivorous fishes, and that the most common building material, *Acrochaetium,* is an important part of the diet of fishes of the genus *Zebrasoma*. No one has remarked that the most common building material of *A. pachychirus* and *A. frontalis (Plectonema wollesi* of Cowles and *Oscillaria* of Fishelson, *Lyngbya majuscula* and *L. sordida* of B&B, all possibly now *Microcoleus spp.*) may be highly toxic to many animals (see for example Moikeha and Chu, 1971:8) and may therefore confer protection from predation to the tube dwellers. Fishelson has remarked that the tubes constitute a microhabitat containing "numerous unicellular algae as well as various ciliates, foraminifera, nauplii and adult micro-crustaceans." When it was slit either the male or both members of the pair would repair it. Fishelson implied (by lack of other designation) that the large chela was used to pull the tube together while the maxillipeds were used to "seal it by rapid sewing motions"; both Cowles and Bowers found the shrimp used the slender flexible second pair of chelae to interlace the filaments of algae from one side to the other. All three authors observed the shrimp form new tubes from loose algal fragments, but only Bowers gives details of how the first fragments are interwoven, again by the second legs, into the initial mat. Fishelson believed that the tubes are more than interwoven "but are also held together in various spots by a sticky substance which seems to be produced by the inhabiting shrimp." Cowles believed the tubes were attached to the underside of rocks by mere entaglement.

Aside from Fishelson's remarks on the use of the third maxillipeds to "sew" the split tubes as quoted above, no one has remarked on the function of the highly modified small chela and setiferous maxillipeds.

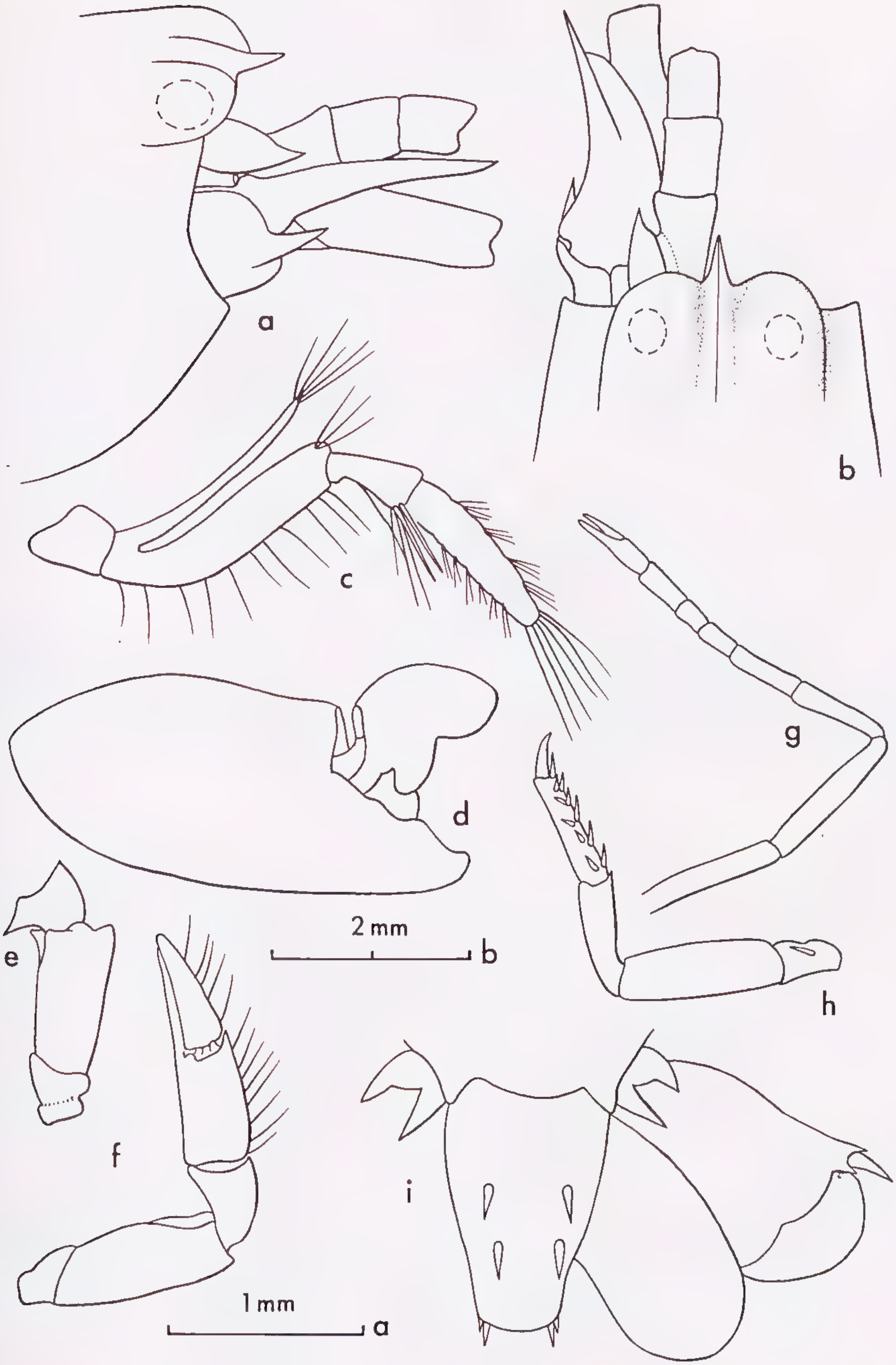

Fig. 24 *Alpheus ovaliceps* Coutière
15 mm female from BAU 29. **a, b.** Anterior region, lateral and dorsal view; **c.** third maxillped; **d, e.** large chelped, chela, lateral face and merus, medial face; **f.** small cheliped, lateral face; **g.** second leg; **h.** third leg; **i.** telson and uropods. a, b, c, i scale a; d, e, f, g, h scale b.

Alpheus ovaliceps Coutière
Fig. 24

Alpheus ovaliceps Coutière, 1905a:888, pl. 77, fig. 27. Banner, 1956:356, fig. 18. Banner and Banner, 1967:275.

SPECIMENS EXAMINED: 3 specimens from BAU 29.

DIAGNOSIS: Rostrum acute, reaching to middle of visible part of first antennular article, with rounded carina extending posteriorly to behind level of eyes. Orbitorostral gooves only moderately deep. Anterior margin of orbital hoods rounded and curving posteriorly towards base of rostrum. Antennular articles nearly equal, second antennular article 1.4 times as long as broad. Stylocerite acute, not reaching end of first antennular article. Outer margin of scaphocerite concave, lateral tooth extending nearly to length of third article past that article; squamous portion narrow, reaching to end of third antennular article. Carpocerite as long as tip of lateral tooth of scaphocerite. Tooth on basicerite strong and reaching beyond stylocerite.

Articles of third maxilliped with ratio of 10:4:7. Third article 4.6 times as long as broad near base. Tip of third article bearing a brush of long hairs, medial face bearing usual rows of setae. Distal end of inferior margin of second article bearing 2 long heavy bristles and a few long setae.

Large chela cylindrical, 2.4 times as long as broad with fingers occupying the distal third. Dactylus heavy with distal tip obtuse, slightly overhanging pollex when closed. Merus 2.2 times as long as broad, distal margin not projected. Small cheliped not sexually dimorphic. Chela rounded in section, 3 times as long as broad with fingers and palm nearly equal. Superior portion of innner face of palm somewhat hirsute.

Carpal articles of second leg with ratio: 10:8:4:4:5.

Ischium of third leg with a spine. Merus broadened in middle without inferodistal tooth, 3 times as long as broad. Carpus 0.7 as long as merus, superodistal margin projecting but rounded, inferodistal margin with acute tooth. Propodus 0.7 as long as merus, bearing on its inferior margin 5 pairs of spines and a pair distally. Dactylus simple, 0.4 as long as propodus.

Pleura of first abdominal somite of male rounded at tip.

Telson 2 times as long as posterior margin is broad. Inner spine of posterolateral pair 2 times as long as outer spine. Articulation of outer uropod broadly scalloped.

DISCUSSION: We have previously remarked upon consistent differences between the "Pacific form" of this species (*loc. cit.*) and the specimen from Minikoi originally described by Coutière. These include in the Minikoi holotype the tapering of the palm towards the dactylar articulation, and a slight transverse groove proximal to the articulation in the large chela, and a dark brown spine on the uropod in Coutière's specimen. Further it has not been previously remarked upon that in the holotype the palmar adhesive plaque is set at an angle to the axis of the palm, permitting the heavy dactylus to be raised to an angle greater than 90°. In contrast, all Pacific specimens we have seen have the palm of the large chela without a taper towards the dactylus and without a transverse groove proximal to the dactylus. They also have the adhesive plaque set at about 90° to the axis of the palm and a slightly more slender dactylus, and all bear a colourless spine on the outer uropod. The 3

specimens from Australia, as well as several specimens from the southern Philippines, agree with the other specimens from the Pacific. All Pacific specimens have the two heavy bristles on the second article of the maxilliped as was described and figured by Coutière. We are now approaching the opinion that the "Pacific form" should be separated from the Indian Ocean form described by Coutière either at the specific or subspecific level, but we have again decided to defer the separation to see if we have additional specimens from the Indian Ocean in the unstudied collection we now have available.

BIOLOGICAL NOTES: Coutière's specimens from Minikoi and Chagos were dredged, but the other specimens in our collections were from dead coral heads from water not over 15 feet deep. The Australian specimens came from a rubble covered reef flat. The largest specimen we have seen was 20 mm long.

AUSTRALIAN DISTRIBUTION: Our 3 specimens came from Rudder Reef off Port Douglas, Qld.

GENERAL DISTRIBUTION: Minikoi Atoll, Chagos, Philippines, Mariana, Marshall, Phoenix, Tonga, Samoa and Society islands.

Alpheus frontalis Milne-Edwards
Figs. 23 l,m; 25

Alpheus frontalis H. Milne-Edwards, 1837:356*. Ortmann, 1890:488. Tiwari, 1963:294, fig. 15. Fishelson, 1966:98, figs. 1-3. Miya, 1974:135, pl. 23, figs. D-G.

Alpheus latifrons A. Milne-Edwards, 1873:87. De Man, 1888a:521, pl. 22, fig. 4; 1890:119, pl. 6, fig. 15.

Betaeus utricola Richters, 1880:164, pl. 17, fig. 34, 35.

Alpheus frontalis Zehntner, 1894:200. [Partim]

Previous Australian records:
White, 1847:75. Torres Straits.
Haswell, 1882b:188. Australia. [Translation of original description.]
Coutière, 1900:414. Murray Is., Torres Straits.
McNeill, 1968:16. North Queensland.

SPECIMENS EXAMINED: 1 specimen from AM 74 (AM P. 27498); 1, AM 94 (AM P. 27468); 1, AM 142 (AM P. 27469); 2, AM 425 (AM P. 27772); 2, AM 432 (AM P. 27331); 2, AM P. 4303; 4, AM P. 7440; 1, AM P. 13554; 8, AM P. 13572; 1, AM P. 27783; 1, WM 204-65.

DIAGNOSIS: Anterior margin of carapace extending between orbits as a shelf-like projection, vaulted in profile carrying rounded dorsal carina extending to base of eyes. Eyehoods inflated, forming moderately deep orbitorostral grooves. At least half of first antennular article covered by anterior projection, visible section one-third as long as second; second article almost 3 times as long as broad; third article 0.5 as long as second. Lateral margins of second and third articles armed with a fringe of short setiferous bristles. Stylocerite rounded, without tooth and reaching only to middle of first

*Several early authors attributed the original description of *A. frontalis* to Thomas Say. However, Holthuis' compilation of the carcinological works of Thomas Say (1969) leaves little doubt that Say never mentioned *A. frontalis* in any of his works on Crustacea, the last of which was published in 1818. Dr F. A. Chace Jr. (personal communication) has pointed out to us that the error arose from Milne-Edwards himself (*loc. cit.*). Milne-Edwards misplaced his footnote 2, attributing authorship to Say, from *A. minus* where it belongs to his own *A. frontalis* listed immediately below.

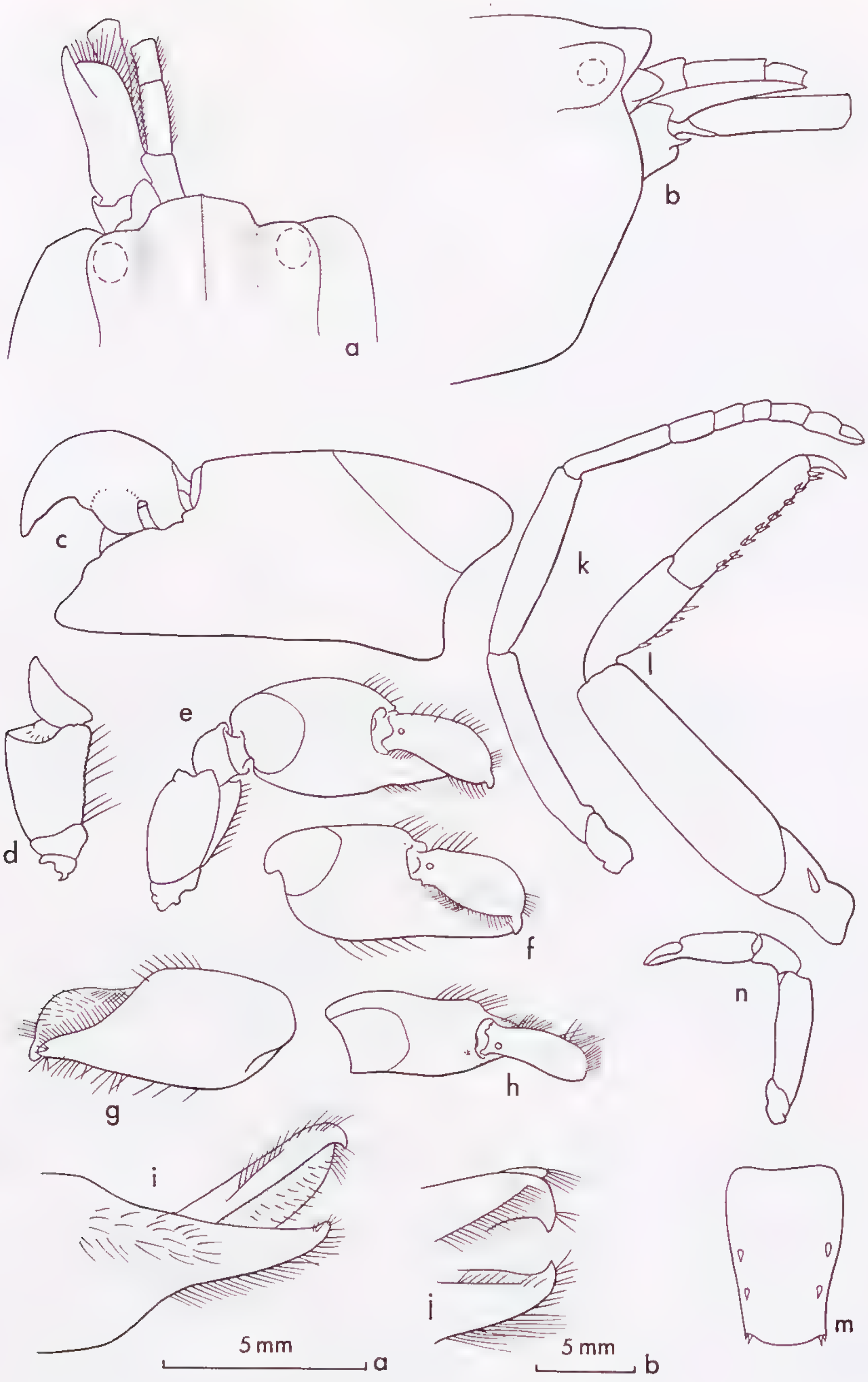

Fig. 25 *Alpheus frontalis* Milne-Edwards
37 mm male from AM P. 13572. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela, lateral face, and merus, medial face; **e.** small cheliped, lateral view, merus held flat; **f.** small chela, lateral face, held flat; **g, h.** small chela medial and superior face; **i.** small chela, inferior face; **j.** small chela, inferolateral face; **k.** second leg; **l.** third leg; **m.** telson. 45 mm female from AM 432. **n.** Small cheliped, lateral face. a, b, i, j, k, l, m scale a; c, d, e, f, g, h, n scale b.

antennular article. Lateral tooth of scaphocerite strong, tip curved slightly medially and reaching to end of antennular peduncle; squamous portion broad, reaching past middle of third antennular article. Carpocerite reaching length of third article past that article. Inferior margin of basicerite with a small acute tooth.

Third maxillipeds stout, ratio of articles: 10:4:7. Second article broader than long, with large setiferous lobe on inferior margin. Third article 1.7 times as long as broad, compressed and acutely triangular in section with inferior margin knife-like and superior margin somewhat thicker; long setae on both margins, with most equal to article in length; setae more dense on inferior margin.

Large chela massive, subcylindrical, without grooves, 2.3 times as long as broad, fingers occupying the distal 0.3. Plunger of dactylus long, tip of dactylus strongly curved and extending slightly beyond pollex when closed. Entire surface of chela covered with minute papillae. Merus nearly as long as broad, superodistal margin not projected. Inferointernal margin with fine irregular teeth and bearing long fine setae; distal angles not projecting.

Small chelipeds sexually dimorphic. Small chela of males about 0.6 as long as large chela, stout, almost 2.4 times as broad, with fingers approximately equal in length to palm. Palm compressed, margins rounded with slight rounded longitudinal depressions on either side of low, rounded crest leading to palmar adhesive plaque, and similar shallow depression on lateral face of base of pollex; palm with only scattered setae. Articular hinge of dactylus set at 45° to vertical axis of palm, closing on pollex from superolateral angle; dactylus broadly expanded, almost petal-like with slight superior ridge distally that terminates in strong, sharply curved terminal tooth; tooth continued on oppositive face of dactylus as a heavy "V"-shaped ridge; tip of tooth with sharp shearing edge that slides past comparable edge on terminal tooth of pollex. Rounded margin of dactylus on either side of terminal tooth with dense row of setiferous bristles; other bristles along margins and scattered softer setae on flattened oppositive face superior to ridge. Pollex slightly expanded proximally, tapering to curved terminal tooth, with groove on oppositive face to accommodate ridge of dactylus; inferior margin near palm with numerous long setae; inner margin with row of setiferous bristles of moderate length and with row of shorter setae on proximal portion of lateral margin. Palm and dactylus with adhesive plaques.

Merus similar to that of large cheliped. Small chela of female unmodified, less than half length of chela of male of corresponding size, with palm cylindrical, 3.7 times as long as broad, fingers slender and tapering; fingers about half length of palm. Merus 3.3 times as long as broad, slightly longer than chela and almost 3 times as long as carpus.

Carpal articles of second leg with ratio: 10:4:2:2:3.

Ischium of third leg with spine. Merus unarmed, 3.5 times as long as broad. Carpus 0.4 as long as merus, terminating inferiorly in acute, superiorly in obtuse tooth. Propodus 0.5 as long as merus and bearing on its inferior margin 7 pairs of spines and a pair distally. Dactylus simple, curved.

Posterior margin of first abdominal pleura of male rounded, but more narrow than in female.

Telson 2.3 times as long as posterior margin is wide. Spines on dorsal surface small, anterior pair placed at middle. Outer spine of posterior pair very small. Articulation of outer uropod straight, not scalloped.

DISCUSSION: The shape of the anterior margin of the carapace is variable in this

species. It is sometimes shorter than in the specimen figured, sometimes slightly emarginate and the sharpness of the carina is also variable. De Man (1911:fig. 79, 79a, b) adequately illustrates this variation. In immature males in this collection the small chelae have only a minimal development of sexual dimorphic characters, a condition already remarked upon (B&B, 1968:286). The usual development of the anterior region of the carapace in spite of its variation makes this species easy to separate from all other species. The 10 mm female from Ambon mentioned by Zehntner (1894:200) was not *A. frontalis* as the first article of the second leg is a third the length of the second article, a condition never approached by this species.

BIOLOGICAL NOTES: For the tube dwelling habits of *A. frontalis* see discussion under the Crinitus Group. As this species appears to be an obligatory commensal in tubes of algae, we suggest that the label of one of Miya's specimens (1974:138) which stated that it was found as a commensal with *Tridacna crocea* was in error.

There appears to be some variation in the colour patterns. Bruce (1975:24, fig. 4) published a beautiful colour photo of a specimen from Mombasa, Kenya which was dark purple and violet and sprinkled with pale lavender and white spots. In a personal communication he stated that this species is ". . . quite common here on Heron Island (Australia) and the colour pattern is still essentially the same, possibly slightly paler only". This is similar to the colour pattern reported by Miya (1974:137) for specimens from the Ryukyus. Fishelson reports his specimens from the Red Sea have ". . . pale transparent bodies, and the only blackish spots are the eyes and stomach. On both sides along the dorsum, there are two rows of white spots on each tergite. The chelae are marbly . . ." However, we cited (1968:286) a report from Dr Cadet Hand that specimens of *A. frontalis* from Kapingamarangi in the Caroline Islands were "purple with a red tail and had blue spots on their bodies". Our specimens from the Philippines were pale brown.

This species ranges in depth from the immediate subtidal to appreciable depths, 130 m according to Miya (1974:138), and from a dredge haul from 20-80 fathoms according to Coutière (1921:425). We have specimens up to 45 mm in length.

AUSTRALIAN DISTRIBUTION: In western Australia we have a specimen from Northwest Cape, in eastern Australia we have specimens from the Torres Straits and along the Great Barrier Reef from the Coral Sea to Heron Island.

GENERAL DISTRIBUTION: This species ranges across the Indo-Pacific from East Africa to the Society Islands. It does not occur in Hawaii.

Alpheus pachychirus Stimpson
Figs 23 j, k; 26

Alpheus pachychirus Stimpson, 1861:30. De Man, 1890:116, pl. 6, fig. 14. Ortmann, 1890:487, pl. 36, figs. 17 a-k. Cowles, 1913: 121, figs. 1, 2.

Previous Australian records:
Coutière, 1900:414. Murray Is., Torres Straits.

SPECIMENS EXAMINED: 1 specimen from AM 74 (AM P. 27501); 1, AM 305 (AM P. 27780); 2, AM P. 7521; 2 AM P. 13568; 2, BAU 31.

DIAGNOSIS: Frontal margin projecting and broadly convex across front from orbital hood to orbital hood, with only a trace of orbitorostral concavity and only a slight obtuse triangle for rostrum. Rostrum bearing low, but distinct, carina reaching posterior to eyes. Orbital hoods inflated, orbitorostral area almost flat.

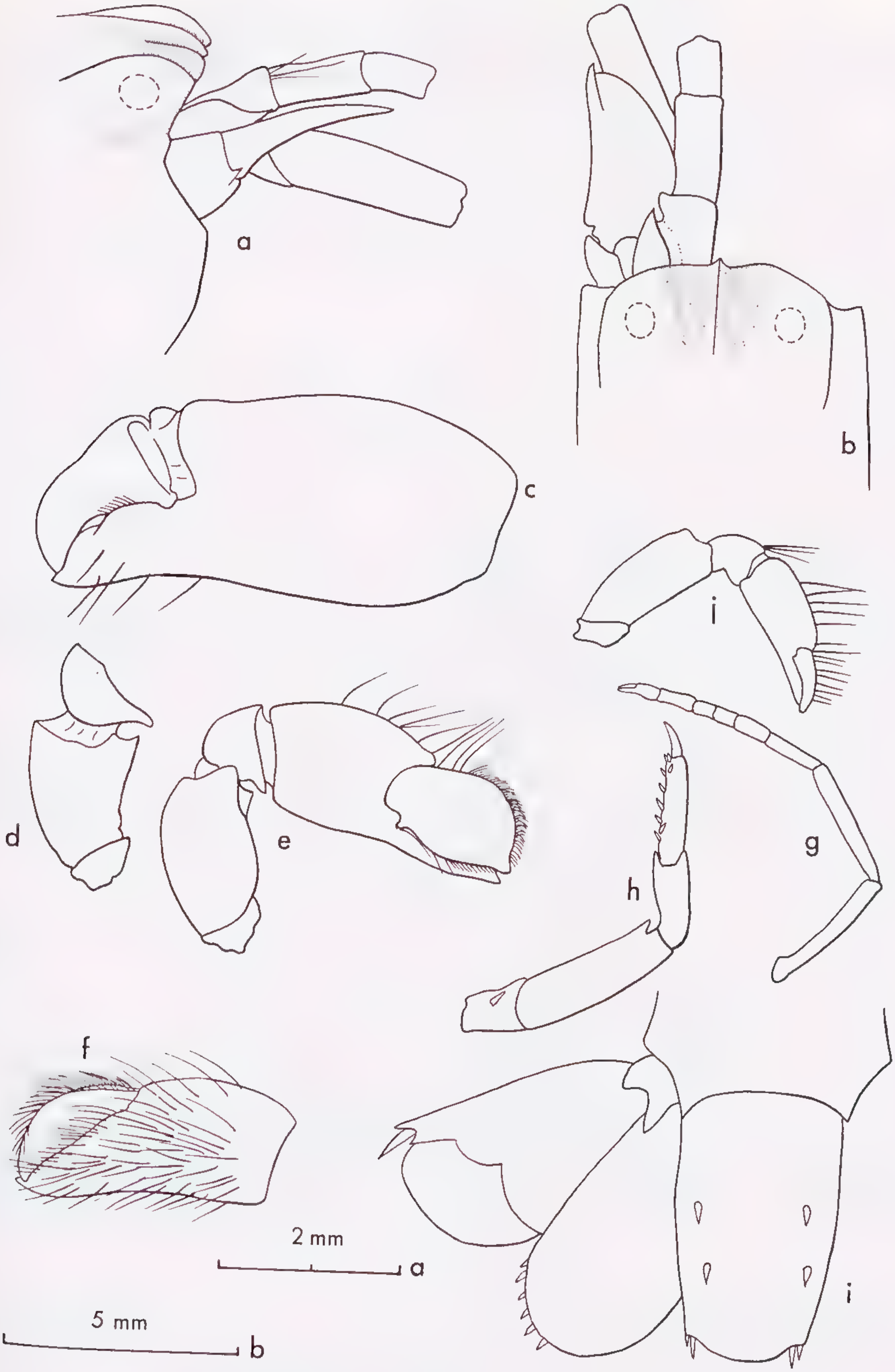

Fig. 26 *Alpheus pachychirus* Stimpson
20 mm male from AM P. 7521. **a, b.** Anterior region, lateral and dorsal view; **c, d.** large cheliped, lateral face and merus, medial face; **e.** small chela, lateral face; **f.** small chela, medial face; **g.** second leg; **h.** third leg; **i.** telson and uropods. 20 mm female from AM P. 7521. **j.** Small cheliped, lateral face. a, b, i scale a; c, d, e, f, g, h, j scale b.

Antennular peduncle with visible part of first antennular article 0.7 as long as second which is 2.3 times as long as broad. Third article 0.4 as long as second. Stylocerite acute, short, not reaching end of first antennular article. Outer margin of scaphocerite nearly straight, lateral tooth curved inward at tip and reaching middle of third antennular article. Squamous portion broad, a little shorter than lateral tooth. Carpocerite reaching well beyond antennular peduncle. Basicerite with small acute lateral tooth.

Third maxilliped stout; second article 1.4 times as long as broad and 0.3 as long as third article. Third article 2.4 times as long as broad, flattened and paddle-shaped. Margins of both second and third articles bearing numerous long bristles with a patch of longer bristles distally.

Large chela cylindrical, 2.3 times as long as broad; dactylus, which is directed slightly laterally, 0.3 total length of chela. Chela of female 0.7 length of that of male of comparable size. Dactylus obtuse, but not truncate distally. Merus 1.5 times as long as wide distally, inferointernal margins without spines, but distally armed wtih a small acute tooth.

Small chela sexually dimorphic. In the male dactylus opening lateral to axis of palm, 1.5 times as long as broad, spatulate with oppositive face concave and with ridge ending in strong, curved and acute distal tooth (compare to figs. 25 e-j for *A. frontalis*); margins bearing dense setiferous bristles. Inferior portions of distal palm and proximal pollex bearing numerous long setae. Merus 1.5 times as long as broad, without teeth distally. Small chela of female 2.7 times as longs as broad with fingers 0.6 as long as palm. Inner face near superior margin bearing fine setae. Merus similar to that of male.

Carpal articles of second leg with a ratio: 10:6:4:3:6.

Ischium of third leg with spine. Merus 3.3 times as long as broad with small acute tooth on inferodistal margin. Carpus 0.5 as long as merus; inferodistal margin projected as acute tooth; superodistal margin projected slightly as rounded tooth. Propodus 0.6 as long as merus, bearing 7 spines on its inferior margin and a pair distally. Dactylus simple, 0.3 as long as propodus. Fourth leg without meral tooth.

First abdominal pleura in male acute, but not hooked.

Telson 2.2 times as long as posterior margin is broad. Anterior margin only 1.3 times wider than posterior. Outer margin of inner uropod bearing 6 spines near posterior section. Articulation of outer uropod scalloped.

DISCUSSION: The separation of this species from closely related forms is given in Table 2. Of the species occurring in Australia, it is closest to *A. frontalis* Milne-Edwards, but from that species it can be separated easily by the nature of the frontal margin of the carapace; it is even closer to *A. clypeatus* Coutière which has not been reported in Australia, and from that species it can best be separated by the shape and the setae of the last article of the third maxilliped. It should be noted that in young males the spatulate condition of the dactylus of the small chela may not be developed.

Fishelson (1966) and Miya (1974) state that they believe the species reported by Cowles (1913) from the Philippines as *A. pachychirus* was *A. frontalis;* this assumption probably was based on the fact that *A. frontalis* was known to make felted or woven tubes of blue-green alga and that habit was unknown for *A. pachychirus* except for Cowles's report. However, we found one pair of *A. pachychirus* in Australia and 6 specimens (some unpaired) in the Philippines all living in such tubes. Therefore, unless other evidence can be offered, we will accept Cowles's determination.

BIOLOGICAL NOTES: This species, which we believe to be largely an obligate

dweller in algal tubes, is discussed with other tube dwellers on p. 94. The species has been found from the lower intertidal to depths of 36 m. from which it was dredged. It reaches the length of 25 mm.

AUSTRALIAN DISTRIBUTION: In northern Australia a specimen was collected from the Torres Straits; in the eastern coast the species ranges from the Coral Sea to off Cooktown and Pt. Douglas, Qld.

GENERAL DISTRIBUTION: Red Sea; Coetivy, Seychelles; Indonesia; Philippines; Ryukyus; Caroline, Marshall, Rotuma, Wake, Palmyra, Tahiti islands.

Alpheus eulimene De Man
Fig. 27

Alpheus eulimene De Man, 1909a:101; 1911:364, fig. 76. Banner, 1956:356. Miya, 1974:146, pl. 27.

SPECIMENS EXAMINED: 1 specimen from AM 305 (AM P. 27777); 2, BAU 29; 2, BAU 30; 1, BAU 31; 2, BAU 42; 2, BAU 48; 1, BAU 55; 1, WM 4985.

DIAGNOSIS: Anterior portion of carapace projecting in front of orbital hoods with portion near rostrum straight in dorsal view and then laterally curving abruptly to meet orbital hoods in their middle. Rostrum broadly triangular and short, scarcely reaching one-fifth length of visible portion of first antennular article; rostral carina extending posteriorly variously from one-third to one-half length of carapace, broadening posteriorly. Second antennular article 1.6 times as long as broad and 1.5 times as long as visible part of first and third articles. Stylocerite acute, not reaching end of first antennular article. Scaphocerite with outer margin concave, squamous portion reduced but protrudant and rounded, reaching to middle of second antennular article, bearing short setae. Carpocerite slender, reaching almost the length of third article past that article. Basicerite without a lateral tooth.

Ratio of articles of third maxilliped: 10:3:7. Inferior margin of first article bearing irregular and usually rounded teeth, inferior margin of second article bearing many setae, particularly distally; third article with tip bearing brush of hairs.

Large chela 2.5 times as long as broad with fingers occupying the distal 0.3. Palm gradually broadening distally, but with abrupt reduction in diameter before dactylar articulation, giving a slight "humped" appearance. Tip of dactylus truncate, overhanging pollex. Merus 1.4 times as long as broad, superior margin not projected, inferointernal margin bearing strong subterminal tooth. Large chela of male much larger than that of female (in one cohabiting pair of equal size (BAU 29), the female chela was 0.6 the length of the male chela).

Small cheliped not sexually dimorphic. Chela 3 times as long as broad, palm broader proximal to midsection, appearing somewhat bulbous from superior aspect. Finger 1.2 times length of palm, rotated to palm so as to open in mediolateral plane, slender and curved laterally; opposing faces varying from nearly flat to markedly concave, with opposing margins serrulate and bearing short setae. Carpus cup-shaped 0.2 as long as chela. Merus 2 times as long as broad, bearing on inferointernal margin an acute terminal tooth.

Carpal articles of second leg with ratio: 10:18:3:3:7.

Ischium of third leg unarmed. Merus 4.0 times as long as broad bearing distally on

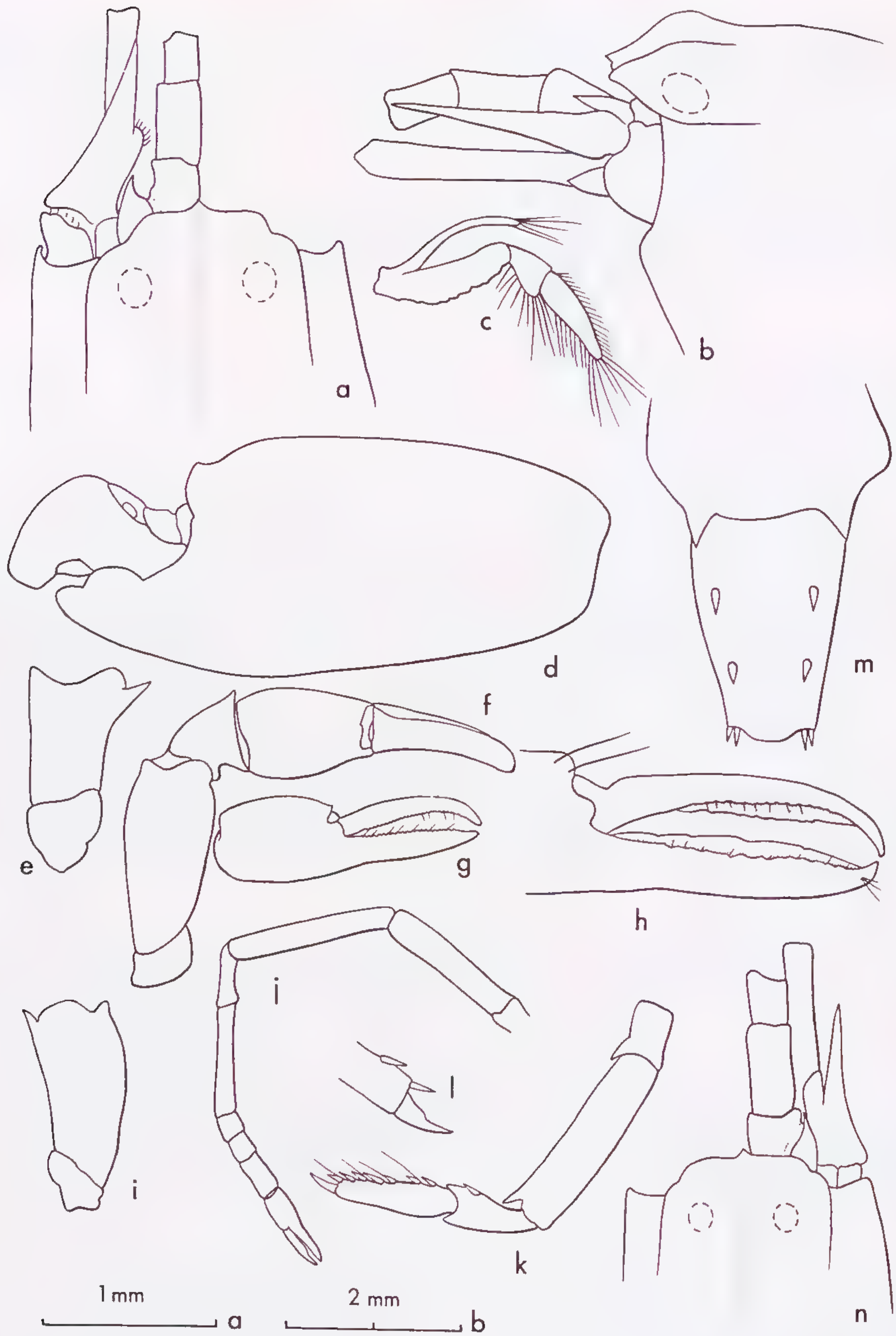

Fig. 27 *Alpheus eulimene* De Man
12 mm male from BAU 29. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d, e.** large chela, lateral face and merus, medial face; **f.** small cheliped, lateral view; **g, h.** small chela, inferior view; distal region enlarged; **i.** merus small chela, medial face; **j.** second leg; **k, l.** third leg and enlarged dactylus; **m.** telson. 15 mm female from BAU 48. **n.** Anterior region, dorsal view. a, b, h, l, m, n scale a; c, d, e, f, g, i, j, k scale b.

the inferior margin a strong acute tooth. Carpus 0.4 as long as merus, distal margins projected, superior projection rounded, inferior projection acute; inferior margin unarmed or bearing one or two spines. Propodus 0.5 as long as merus, bearing on its inferior margin 6 spines and a pair distally; spines interspersed with a few long setae. Dactylus varying from simple to bearing a small acute secondary unguis. Merus of fourth legs unarmed.

Pleura of first abdominal segment of male hooked and acute. Sixth abdominal somite with strong teeth above lateral margins of telson but without tooth in middle. Telson 2.5 times as long as broad; anterior pair of dorsal spines placed just anterior to middle. Inner uropod with spines on distal margin.

DISCUSSION: Four species and one variety within the Crinitus Group are closely related and are known from a very few specimens. They are (in order of date or page priority):

Alpheus styliceps Coutière, 1905a:889, pl. 78, fig. 28 from the Maldives and Laccadives also from the Marshall Islands (B&B 1968:282).
Alpheus stanleyi Coutière, 1908a:207 (repeated with figures, 1921:423, pl. 63, fig. 18) from Amirante, and by Johnson (1962a:52) from the Singapore region.
Alpheus arethusa De Man, 1909a:100 (and 1911:352, fig. 72), known only from Indonesia.
Alpheus eulimene De Man, 1909a (and 1911) (*loc. cit.*), originally reported from Indonesia and subsequently from the Marianas (Banner, 1956:356) and Japan (Miya, 1974:146, pl. 27).
Alpheus stanleyi var. dearmatus De Man, 1910b:287 (and 1911:367, fig. 78), 3 specimens from Indonesia and 11 in our collection from the Philippines (see below).

The species and the one variety are separated by slight differences in characteristics that have been found to be variable in other members of the Crinitus Group and the separation, especially of *A. eulimene* and *A. styliceps,* has been questioned (Banner, 1956 and Miya, 1974). As the ranges of the four species could easily include at least Northern Australian waters, we are presenting a table of characteristics which may be used to separate them, if indeed they are distinct (Table 3).

The principal difference between the two nominal forms of *A. stanleyi* and the three other species lies in the small chelae, with a cylindrical palm and straight fingers that are laterally expanded, with the pollex excavate in the two forms of *A. stanleyi* and with a bulbous palm and narrow curved fingers in the other three. The chelae are not sexually dimorphic.

All the specimens we have from Australia save one (see *A. arethusa* De Man) fit the description of *A. eulimene* the best. However, the following variations were found in the small sample of 12 specimens:

1. The squame varied from nearly vestigial, as depicted in fig. 27a, to reaching almost to end of second antennular article.
2. In the carpus of the second leg the ratios of the first two articles varied from 10:12 to 10:18.
3. In the third leg all meri were armed with an acute distal tooth; 4 specimens had no spines on the carpus while 8 had one or two spines, and the dactylus was either simple or had a small secondary unguis.
4. On the fourth legs, none of the meri had teeth and none of the carpi had spines.

The final decision on the validity of the separation of the three nominal species, *A. styliceps, A. arethusa* and *A. eulimene,* will have to be reserved until more specimens, preferably over a greater geographic range, are studied. However, at present we have

TABLE 3
Characteristics of the species of the *Alpheus styliceps* complex

Characteristic	*A. styliceps* Coutière	*A. stanleyi* Coutière	*A. arethusa* De Man	*A. eulimene* De Man
Length of rostrum to 1 aa[1]	Two-thirds	Middle	First third, minute	First third, minute
Anterior margin of carapace	Projecting, but flowing into rostrum as concave curve	Same as *A. styliceps*	Projecting, almost convex	Projecting and transverse
Stylocerite to 1 aa	Reaching end	Past middle or near end[2]	To about half	Near end
Scaphocerite:				
Lateral spine to 3 aa	Past end	Middle	Past end	Past end
Squame to 2 and 3 aa	0.5 of 2 aa	0.7 of 2 aa	End 2 aa	From 0.2 to near end of 2 aa
Capocerite to 3 aa	Well past	Scarcely past	Well past	Well past
Small chela:				
Palm, viewed above	Bulbous	Sides parallel	Bulbous	Bulbous
Fingers	Narrow, curved inward	Broadened, straight	Narrow, curved inward	Narrow, curved inward
Second leg:				
Ratio, first 2 carpal articles	10:13	10:7	10:16	10:12-10:18
Third leg:				
Merus length:breadth	3.0	5.0	4.0	4.0
Carpal spines	None	None	1	0-2
Dactylus	Simple	Simple	Biunguiculate	Simple to biunguiculate
Fourth leg:				
Distal margin of merus	Tooth	Tooth	Rounded	Rounded
Carpal spines	(Not mentioned)	(Not mentioned)	1-2	None
Pleura, abdominal segments of males	(Not mentioned)	(Not mentioned)	1-4 hooked, last acute	1 hooked, subsequent rounded

1. 1, 2, 3 aa — first, second or third antennular article.
2. *cf.* fig. 18. 18′, Courière, 1921.

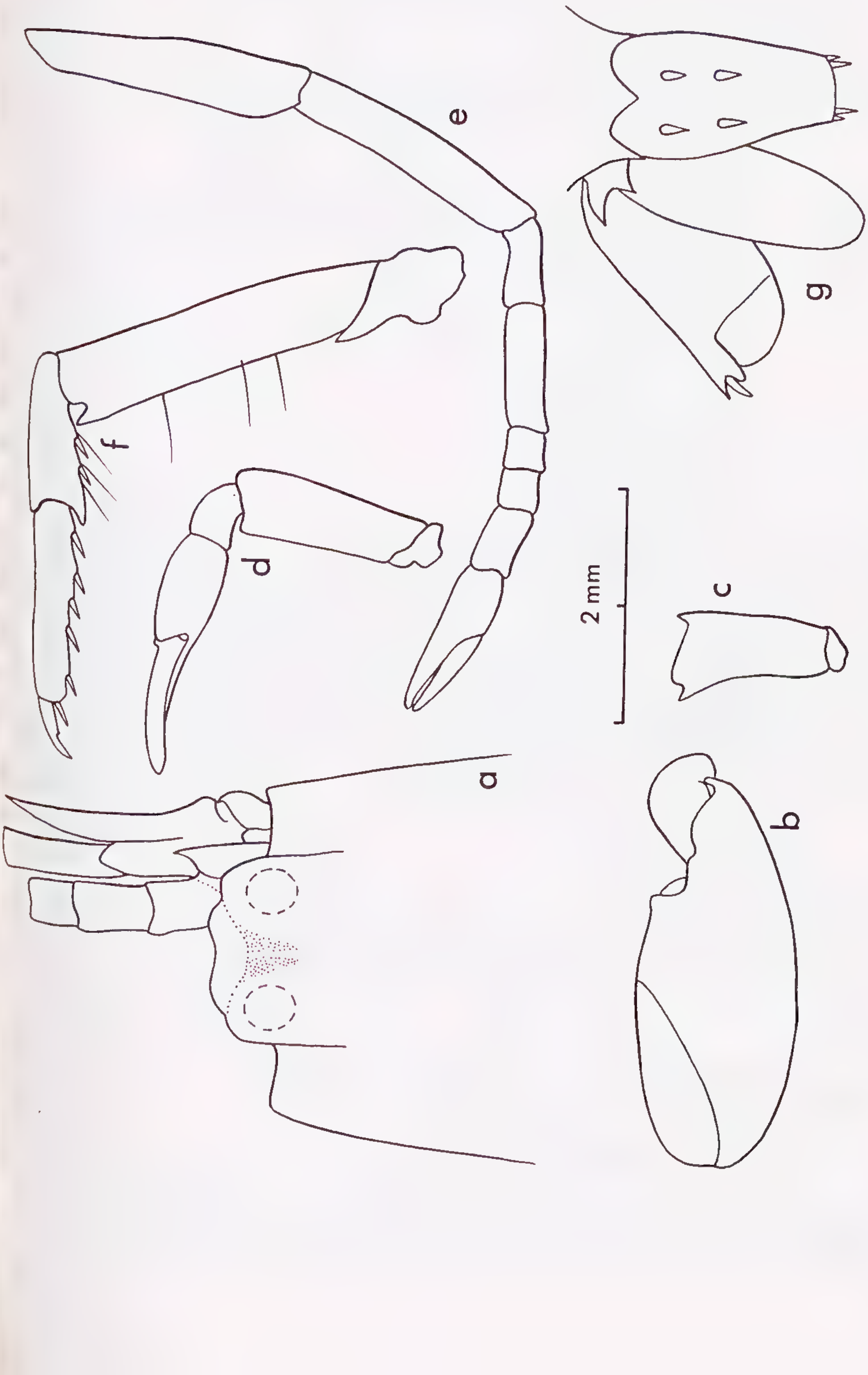

Fig. 28 (?)*Alpheus arethusa* De Man

9 mm female from BAU 53. **a.** Anterior region, dorsal view; **b, c.** large chela, lateral face and merus, medial face; **d.** small cheliped, lateral face; **e.** second leg; **f.** third leg; **g.** telson and uropods. All figures same scale.

doubts that they do indeed represent distinct species. We have reconsidered the 11 Philippine specimens that we originally though to be *A. stanleyi var. dearmatus* and have decided that the different form described by De Man is more likely to be a variety than a subspecies by modern rules. This change will be published in our Philippine paper which may possibly appear before this longer study.

BIOLOGICAL NOTES: De Man's specimens were collected from 83 metres, but our specimens have been collected from dead corals in water not over 15ft. deep. Two of the specimens came from sponges. It is a small species, our largest specimen being only 14 mm.

AUSTRALIAN DISTRIBUTION: On the west coast of Australia we have one specimen from off Geraldton; in the north, a specimen from the Torres Straits and on the east coast specimens from off Port Douglas in northern Queensland to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Maldives, Indonesia, Philippines, Japan, Marianas.

(?) **Alpheus arethusa** De Man
Fig. 28

Alpheus arethusa De Man, 1909a:101; 1911:352, fig. 72.

SPECIMEN EXAMINED: 1 specimen from BAU 53.

DISCUSSION: A single 9 mm female specimen from Heron Island in the available collections lies within the limits of variation of the small collection of *A. eulimene* from Australia except for 3 characteristics: First, the anterior margin of the carapace is shallowly concave where the rostrum should be; recalling the variation previously reported for *A. clypeatus* Coutière from Hawaii (Banner, 1953) we attach no great significance to this. Second, the palm of the small chela is less bulbous than in *A. eulimene*, but this may be due to the small size or to the sex of the specimen. Third, the median posterior margin of the sixth abdominal tergum projects over the telson as a large and definite tooth, a characteristic not found in any of the specimens of *A. eulimene* we have seen. It is for this reason that we have assigned the specimen to this species, but with doubt. As the hooked condition of the abdominal pleura is found only in males, we did not have that corroboration for our identification.

For the separation of this nominal species from the others in the *A. styliceps* complex, see Table 3, p. 108.

BIOLOGICAL NOTES: De Man's specimens were taken from the "reef" and ours was taken from a head of dead coral taken from the reef flat. The species may be small as our specimen was only 9 mm and De Man's 2 specimens were 10 mm.

AUSTRALIAN DISTRIBUTION: Our specimen came from Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: This is the first time this species has been reported since De Man's original specimens from Timor, Indonesia.

Alpheus alcyone De Man
Fig. 29

Alpheus alcyone De Man, 1902:870, pl. 27, fig. 61. Nobili, 1906c:32. De Man, 1911:351 (charact. emend.). Banner, 1966b:107, fig. 36. Miya, 1974:144, pl. 26.

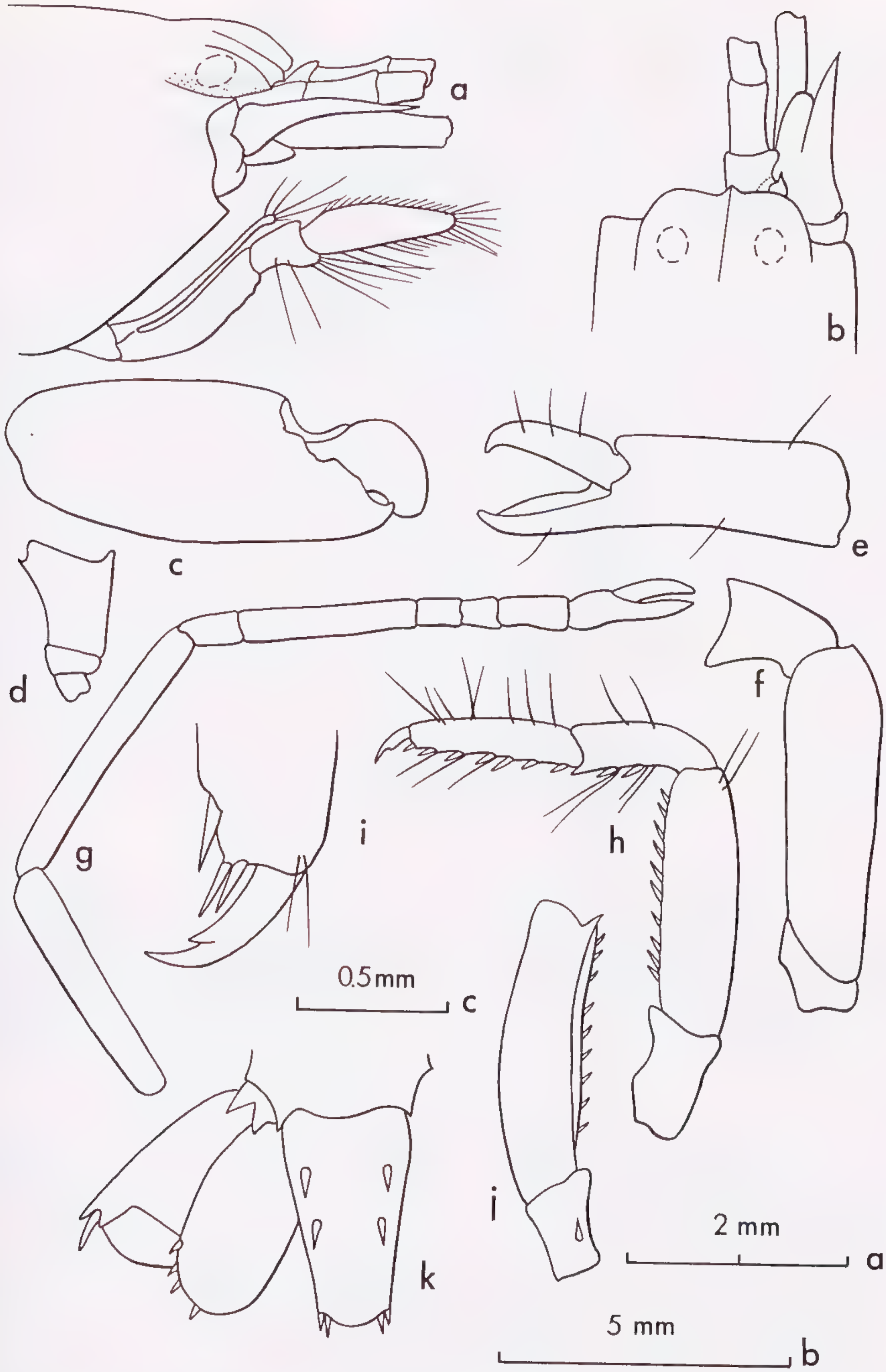

Fig. 29 *Alpheus alcyone* De Man
14 mm male from BAU 55. **a, b.** Anterior region, lateral and dorsal view; **c, d.** large cheliped, chela, lateral face and merus, medial face; **e, f.** small cheliped and merus, lateral face; **g.** second leg; **h, i.** third leg and enlarged dactylus, medial face; **j.** merus third leg, lateral face; **k.** telson and uropods. a, b, e, f, g, h, j, k scale a; c, d scale b; i scale c.

Alpheus aculeipes Coutière, 1905a:892, pl. 79. fig. 31.

Alpheus crinitus Bate, 1888:548, pl. 98, fig. 2. Zehntner, 1894:206 (*Nec* Dana, 1852).

SPECIMENS EXAMINED: 2 specimens from AM 283 (AM P. 27329); 1, AM 298 (AM P. 27769) 2, AM 305 (AM P. 27775); 1, AM 329 (AM P. 27400); 1, BAU 25; 1, BAU 30; 3, BAU 31; 1, BAU 43; 2, BAU 44; 2, BAU 53; 7, BAU 55; 8, BAU 56; 1, BAU 57; 1, JC 30; 1, WM 91-65; 4, WM 183-65; 3, 75 LIZ-1 (AM P. 27897).

DIAGNOSIS: Rostrum small, triangular, hardly exceeding the orbital margin, rostral carina rounded reaching to base of orbits. Anterior margin of carapace slightly concave lateral to rostrum. Visible part of first antennular article and third article subequal, second article 1.5 times longer than third article and 1.6 times as long as broad. Stylocerite with tip acute, small, not reaching end of first antennular article. Scaphocerite with lateral margin concave, lateral tooth reaching to end of antennular peduncle, squamous portion narrow, reaching to end of second antennular article. Carpocerite reaching well beyond end of antennular peduncle. Basicerite without lateral tooth.

Ratio of articles of third maxilliped: 10:4:10. Second article only a little longer than distal section is wide, distoinferior margin bearing a batch of fine setae. Third article 3.5 times as long as broad, broadened in the middle and bearing a tuft of fine setae at tip.

Large chela cylindrical, 2.4 times as broad a long with fingers occupying the distal 0.3. Tip of dactylus truncate, overhanging pollex. Merus a little longer than broad, superodistal margin terminates in a subacute tooth, inferointernal margin in a small acute tooth.

Small chela not sexually dimorphic. Chela 4 times as long as broad, palm 1.7 times longer than fingers. Carpus cup-shaped, almost half as long as palm. Merus 3.4 times as long as broad, not projecting distally.

Ratio of carpal articles of second leg: 10:28:7:7:11.

Ischium of third legs with a small spine. Merus 3.3 times as long as broad; inferoexternal margin terminating in an acute tooth; inferointernal margin bearing 3-12 small spines and no tooth distally. Carpus 0.5 as long as merus bearing on inferior margin 1-4 spines. Distosuperior margin not projected, distoinferior margin terminating in acute tooth. Propodus 0.7 as long as merus, bearing on its inferior margin 6 spines and a pair distally; superior margin bearing long fine setae. Dactylus biunguiculate, 0.2 as long as propodus.

Pleura of first abdominal somite of male hooked.

Telson 2.8 times as long as broad, posterior pair of dorsal spines placed just posterior to middle. Inner uropod with only a few spines on outer distal margin. Articulation of outer uropod straight, not scalloped.

DISCUSSION: While we have not seen De Man's type specimens, these specimens from Australia agree well with his descriptions (1902, 1911) and with the other specimens we have placed under this species in previous studies. We have noted that the second article of the carpus of the second leg varies from 2 to 3 times the length of first, that the number of spines on the merus, carpus and propodus of the third leg is variable (with one specimen carrying only 3 spines on the merus and 1 on the carpus), and that the secondary unguis of these legs varies from a slight shoulder to a pronounced tooth.

De Man's original description of this species was defective and Coutière (1905a) described *A. aculeipes* on differences between his specimens and De Man's original

description. In 1911 De Man reported on the re-examination of his 4 "type specimens" and corrected his earlier errors; this removed the differences and *A. aculeipes* was placed in synonymy.

In the meantime, Nobili (1906b:257) had described a variety, *triphopus* (later spelled *tryphopus* in 1907:355) under *A. aculeipes* from the Tuamotus. On the basis of his at times somewhat ambiguous descriptions, this form may represent a geographical subspecies of *A. alcyone* or, more likely, a separate species which was De Man's 1911 opinion. We examined Nobili's type in the Muséum National d'Histoire Naturelle of Paris and found it to be somewhat desiccated and with only the detached large cheliped of all its pereiopods. As this form was not represented in our collection from the nearby Cook and Society Islands, we defer judgement on its validity as a species until more specimens from the Tuamotus are examined to determine their range of variation.

BIOLOGICAL NOTES: This species has been collected in waters up to 71 fathoms. Although our collections have been made from heads of dead coral that we broke up we feel that these specimens, like so many other members of the Crinitus Group may have been dwelling in sponges. Yaldwyn has supplied the following colour notes for a specimen from One Tree Island (AM 329) "Body, limbs and eggs orange, internal organs green, gut in abdomen white". The largest specimen was 18 mm long.

AUSTRALIAN DISTRIBUTION: In western Australia we have specimens from Carnarvon and Exmouth Gulf; in northern Australia from the Torres Straits, and in eastern Australia from Lizard Island south to the Capricorn Group.

GENERAL DISTRIBUTION: Red Sea, East Africa, Persian Gulf, Maldives, Ceylon, Malaysia, Thailand, Indonesia, Philippines, Japan, Marshall, Caroline, Fiji, Tonga and Samoa Islands.

Alpheus paralcyone Coutière
Fig. 30

Alpheus paralcyone Coutière, 1905a:895, pl. 80, fig. 34. Miya, 1974:139, pl. 24.

Crangon paralcyone Banner, 1953:99, fig. 34.

Crangon laysani Edmondson, 1925:17, fig. 3.

Crangon bucephalus Edmondson, 1925:14 [*PARTIM*].

SPECIMENS EXAMINED: 1 specimen from BAU 10; 2, BAU 15; 2, BAU 17; 1, BAU 31; 2, BAU 33: 6, BAU 43; 2, BAU 55; 1, MM 181; 1, WM 290-65; 1, 75 LIZ-H (AM P. 27914).

DIAGNOSIS: Rostrum short but discrete, a broad triangle extending only slightly beyond anterior margin; with definite, but low rostral carina extending to base of orbital hoods. Orbital hoods slightly inflated, area between orbital hoods and rostral carina flat. Orbitorostral margin slightly concave. Pterygostomial angle projecting but obtuse. Visible part of first and third article of antennular peduncle subequal, second article 1.5 times longer than third and 2 times as long as broad. Stylocerite short, acute, and not reaching end of first antennular article. Scaphocerite with outer margin slightly concave, lateral tooth strong, reaching to near end of third antennular article. Carpocerite reaching more than length of third article past that article. Inferior margin of basicerite with strong acute tooth.

Ratios of articles of third maxilliped 10:3:6. Second article as long as wide in distal part with inferodistal margin bearing many long setae. Third article 2.5 times as long as

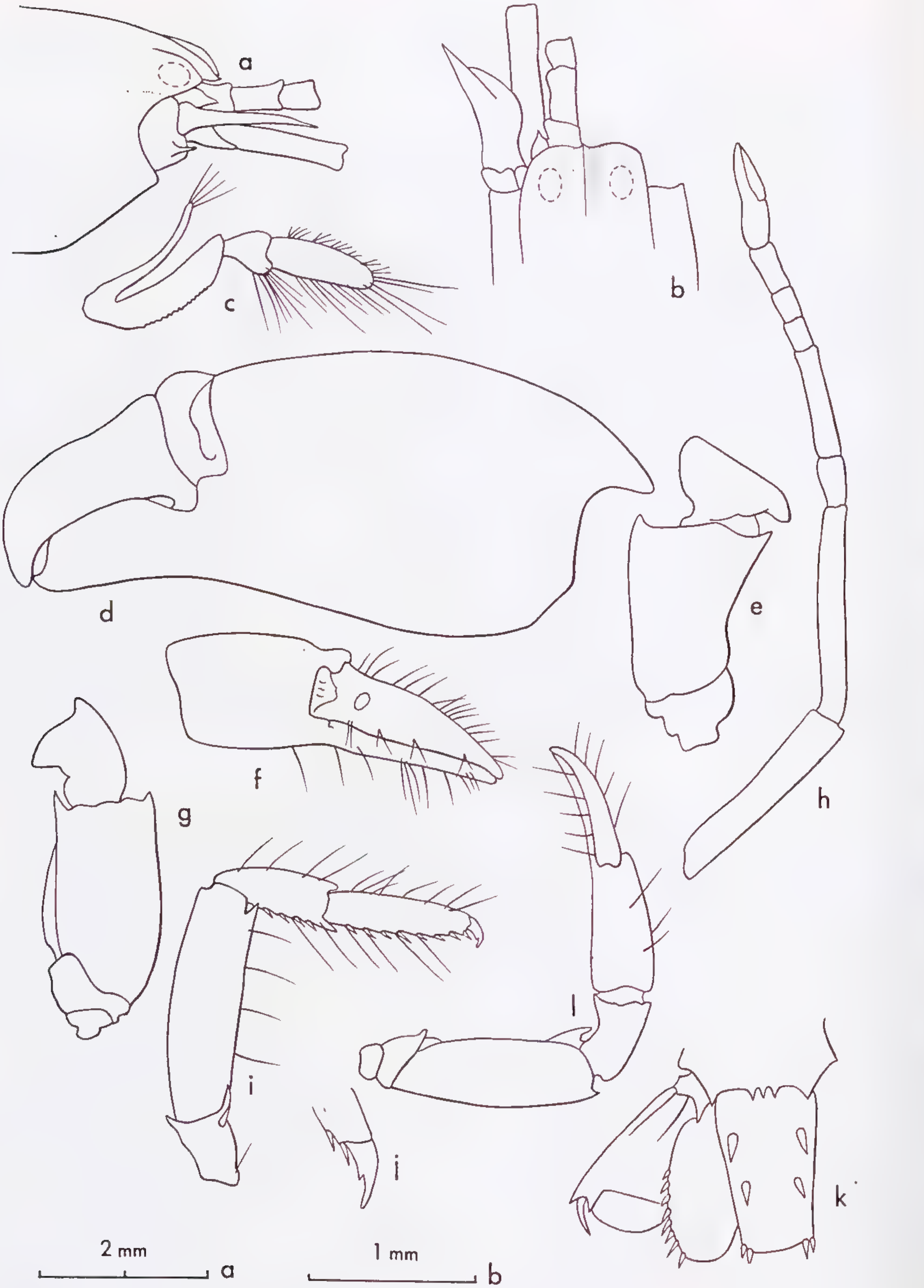

Fig. 30 *Alpheus paralcyone* Coutière
14 mm male from BAU 43. **a, b.** Anterior region, lateral and dorsal view; **c.** third maxilliped; **d, e.** large cheliped, chela, lateral face and merus, medial face; **f, g.** small cheliped, chela, lateral face and merus, medial face; **h.** second leg; **i, j.** third leg and enlarged dactylus; **k.** telson and uropods. 10 mm female from BAU 43. **l,** Small cheliped, lateral face. a, b, c, d, e, f, g, h, i, k, l scale a; j, scale b.

wide, medial face with batches of short stiff setae interspersed on inferior margin with long setae, tip with several long setae.

Large chela cylindrical, 2.3 times as long as broad with fingers occupying distal 0.3. Distal section of chela twisted slightly laterally. Dactylus not carinate, curved, tapering but rounded at tip. Merus 1.3 times as long as broad, superodistal margin with subacute tooth, inferointernal margin with acute distal tooth.

Small chela sexually dimorphic. Male chela 3 times as long as broad, with fingers a little longer than palm. Palm cylindrical with small obtuse projection medial to dactylar articulation. Dactylus slightly broadened from articulation to well past middle at which point it tapers gradually to tip. Both margins of fingers bearing scattered setae. Merus 2 times as long as broad, superior margin projected as small acute tooth; inferointernal margin with a strong acute tooth distally. Female chela more slender, 4 times as long as broad, fingers and palm equal. Palm slightly compressed, bearing distomedially a small obtuse tooth. Dactylus not broadened, tapering gradually to tip. Carpus 0.6 as long as palm. Merus 3 times as long as palm, superior margin projecting as a small acute tooth, inferointernal margin bearing prominent tooth.

Ratio of carpal articles of second leg: 10:23:6:6:10.

Ischium of third leg with spine. Merus 3.5 times as long as broad, bearing an acute tooth distally on inferior margin. Carpus 0.5 as long as merus and bearing on its inferior margin 1-4 small spines; both distal angles projecting, superior rounded, inferior acute. Propodus 0.6 as long as merus, bearing on its inferior margin 7 spines and a pair distally. Dactylus biunguiculate with secondary unguis varying from an acute angle to one-third length of superior unguis. Merus of fourth legs also armed, carpus with but one or two spines.

Pleura of first abdominal somite of male acute. Middle of posterior margin of sixth abdominal tergum bearing 3-4 small acute teeth.

Telson 2.0 times as long as broad. Inner uropod bearing several short spines on outer margin near posterior section. Spine at distal articulation on outer uropod strong, and curved strongly towards midline; articulation straight.

DISCUSSION: The Australian specimens agree very well with Coutière's original description (holotype is missing) except most of our specimens had more than two teeth on the posterior margin of the sixth abdominal somite. Banner (1953:99, fig. 34) described and figured specimens of this species from Hawaii. On the basis of a large collection he found the following characters variable:

1. The length of the second antennular article varied from 1.4 to 2.0 times the length of the visible portion of the first.
2. The tip of the stylocerite reached from markedly shorter than the first antennular article to equal to it.
3. The relative lengths of the antennular peduncle, carpocerite and scaphocerite showed considerable variation.
4. The second carpal article of the second leg varied from 2 to 4 times as long as the first.
5. The number of spines on the carpus of the third leg varied from 1 to 5.

This species also varies in the number of teeth above the articulation of the telson, with Miya (1974) reporting from 2 to 7 on specimens from Japan, De Man (1911) reporting none to several in Indonesian specimens, and Banner (1953) reporting none at all from Hawaii.

BIOLOGICAL NOTES: This species has been collected from dead coral heads in the immediate subtidal to as deep as 90 fathoms west of Carnarvon in Western Australia. Banner (1953) reported on several deep water collections made by the *Albatross* near Hawaii. Johnson (1962b:283) reported this species as very common in the beach sponges of Singapore. It is a small species attaining a maximum length of 15 mm.

AUSTRALIAN DISTRIBUTION: Off Carnarvon, W.A.: in northern Australia from the Torres Straits; off Queensland from Lizard Island south to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Maldives, Seychelles, Ceylon, Indonesia, Singapore, Thailand, Philippines, Japan, and across the central Pacific to Hawaii.

Alpheus spongiarum Coutière
Fig. 31

Alpheus spongiarum Coutière, 1897a:236. Miya, 1974:148, pl. 28.
Alpheus paraculeipes Coutière 1905a:894, pl. 80, fig. 32. Pearson, 1905:84; 1911:356. Green, 1972:67.

Previous Australian Records:
Coutière 1900:413. Torres Straits.
Green, 1972:67. Houtman Abrolhos.

SPECIMENS EXAMINED: 1 specimen from AC S. 2; 1, AM 247 (AM P. 27535); 1, BAU 21; 4, BAU 33; 2, BAU 42; 1, BAU 43; 1, BAU 44; 3, BAU 55; 1, BAU 56; 1, WM 81-65; 1, WM 91-65; 1, WM 114-65; 1, WM 144-65; 1, WM 226-65; 1, WM 264-65; 4, WM 279-65; 5, 75 LIZ-1 (AM P. 27895).

DIAGNOSIS: Rostrum of moderate size, triangular, with rostral crest reaching to base of eyes. Orbitorostral grooves shallow and rounded, orbitorostral margin almost straight. First and third antennular articles almost equal in length, second article twice as long as broad and almost twice length of visible portion of first article; stylocerite with acute tip not reaching to end of first article. Outer margin of scaphocerite slightly concave, squamous portion vestigial, reaching only to end of first quarter of second antennular article. Lateral tooth reaching to middle of third antennular article. Carpocerite reaching slightly more than half the length of the third article past that article.

Third maxilliped similar to *A. paralcyone* (p. 113).

Large chela cylindrical, 2.2 times as long as broad with fingers occupying the distal 0.3. Tips of dactylus obtuse. Merus 2 times as long as broad, superior margin projecting, acute, inferointernal margin bearing small acute tooth distally.

Small chela not sexually dimorphic, cylindrical, 3.4 times as long as broad with fingers 0.7 as long as palm. Carpus 0.6 as long as palm. Merus 0.75 as long as chela, 2.5 times as long as broad, with inferointernal margin bearing small, acute, tooth.

Carpal articles of second legs with ratio: 10:20:3:3:9.

Ischium of third leg unarmed. Merus 4.3 times as long as broad, triangular in section; inferoexternal margins bearing 10-12 long fine setae with an acute tooth distally but no spines; inferointernal margin bearing numerous short setae. Carpus 0.5 as long as merus with both margins projecting as blunt teeth and bearing setae and often 1 or 2 spines on inferior margin and a row of patches of short setae medial to this. Propodus 0.7 as long as merus and bearing on its inferior margin 8 spines directed distally with the tip often

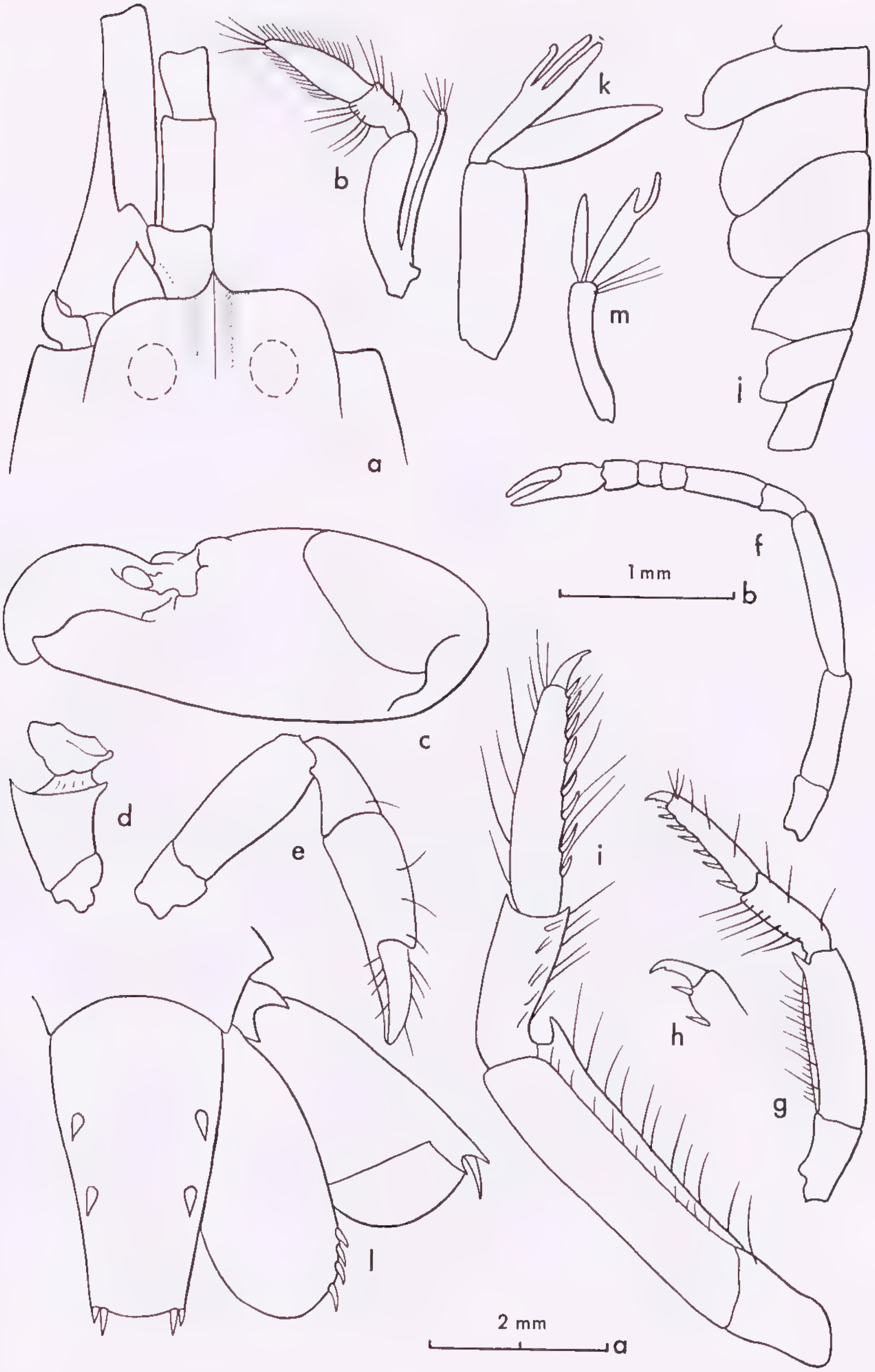

Fig. 31 *Alpheus spongiarum* Coutière
12 mm male from BAU 44. **a.** Anterior region, dorsal view; **b.** third maxilliped; **c, d.** large cheliped, chela, lateral face and merus, medial face; **e.** small cheliped, lateral face; **f.** second leg; **g, h.** third leg and enlarged dactylus lateral face; **i.** third leg, enlarged, medial face; **j.** abdomen, lateral face; **k.** second pleopod; **l.** telson and uropods. 10 mm female from BAU 55. **m.** Second pleopod. b, c, d, e, f, g scale a; a, h, i, j, k, l, m scale b.

turned towards the axis of the propodus, spines interspersed with long hairs. Dactylus usually biunguiculate with secondary unguis small.

Appendix masculina in second pleopod of male arising near middle of endopod and extending slightly past endopod. *Appendix interna* in female arising in distal third of endopod, curving inward and extending well past endopod.

First abdominal pleura of male hooked.

Telson 3.2 times as long as posterior margin is broad. Anterior pair of dorsal spines placed just anterior to middle. Posterolateral margin of inner uropod armed with a few curved spines. Articulation of outer uropod not scalloped.

DISCUSSION: Coutière (1905a) described *A. paraculeipes* as closely related to his earlier species, *A. spongiarum,* from which it differed only in the characteristics of the third leg; he illustrated the third legs of the two species in figures 32f and 33.

De Man (1911:364) sugggested that the two nominal species were "varieties of one and the same species." Miya (1974:150) studied 7 specimens from Japan and concluded that his specimens were also intermediate between the two and placed *A. paraculeipes* in synonymy to *A. spongiarum.* With 26 specimens in the Australian collections we made a detailed study of all characteristics used by Coutière for the differentiation between the species, and found all were variable, but that the Australian specimens were mostly closer to the form described as *A. spongiarum.* Thus, the dactylus usually carried a secondary unguis which varied from a definite tooth to a minor angular projection; only in 3 specimens was the secondary unguis entirely lacking as Coutière had reported for *A. paraculeipes.*

We have remarked before upon the variation that is found in other species of alpheids that are symbiotic, especially those found hidden in spongocoels. (See for example, the discussion under *Synalpheus lophodactylus* Coutière in B&B 1975:352) and we would expect that the slight differences listed by Coutière would be within these limits of variation. While we have not bridged all of the differences in the present collection, we still accept Miya's designation of *A. paraculeipes* as a synonym.

We have re-examined the specimen from the Houtman Abrolhos that Green (1972) reported that we had identified for him with reservations as *A. paraculeipes* and found it to be within the range of variation for *A. spongiarum.*

BIOLOGICAL NOTES: There is little doubt that this species lives entirely in sponges. Johnson (1962b:283) reported it living in the beach sponge *Suberites inconstans.* A "cotype" of this species at the University Museum of Zoology, Cambridge (England) had a note in the bottle indicating it was commensal with the sponge, *Hippospongia reticulata.* It has been found from the intertidal to as deep as 23 fathoms. Coutière reported that his original specimen from Djibouti was: *"Incolore, sauf une bande rouge cerise clair sur le thorax et sur les 2e and 3e anneaux de l'abdomen. Bout des pinces violet foncé passant au rouge sur la paume."* Miya reported that the chelipeds on the specimens from Japan were dark to light red and all of the abdominal segments were banded with red. It is not a large species, our largest specimen being 18 mm.

AUSTRALIAN DISTRIBUTION: We have specimens from western Australia from Cockburn Sound, near Perth, to Dampier Archipelago and Cape Jaubert. In the north it has been collected in Torres Straits and Gulf of Carpentaria. In eastern Australia it was collected from Lizard Island, Qld, south to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Djibouti, Gulf of Aden, Maldives and Laccadives, Ceylon, Singapore, Indonesia, Japan.

Fig. 32 *Alpheus bucephalus* Coutière
17 mm male from BAU 20. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large cheliped, chela, lateral face and merus, medial face; **e, f.** small chela, and merus, lateral face; **g.** second leg; **h.** third leg; **i.** telson and uropods. 19 mm female from BAU 20. **j.** Small cheliped, lateral face. 16 mm male from BAU 20. **k.** Distal end, large chela, medial face. All drawings same scale.

Alpheus bucephalus Coutière
Figs. 23 d-f; 32

Alpheus bucephalus Coutière. 1905a:890, pl. 78, fig. 29. Banner and Banner, 1966b:110, fig. 38.

Alpheus consobrinus De Man, 1908:101; 1911:360, fig. 75.

Alpheus crinitus Coutière, 1900:413. (*Nec* Dana, 1852).

Crangon bucephalus Edmondson, 1925:14. (*Partim =A. paralcyone* Coutière).

Crangon bucephalus var. Rathbun, 1914:654.

Confer: Banner, 1957:201.

Previous Australian Records:
Coutière, 1900:413. Torres Straits (as *A. crinitus Dana*).
Rathbun, 1914:654. Monte Bello Island.
Balss, 1921:9. Cape Jaubert.

SPECIMENS EXAMINED: 5 specimens from AM 123 (AM P. 27325); 1, AM 238 (AM P. 27326); 1, AM 332 (AM P. 27401); 1, AM 460 (AM P. 27788); 1, BAU 10; 2, BAU 11; 4, BAU 16; 18, BAU 20; 2, BAU 21; 4, BAU 23; 9, BAU 24; 5, BAU 25; 23, BAU 27; 10, BAU 28; 14, BAU 29; 1, BAU 30; 2, BAU 33; 1, BAU 41; 3, BAU 42; 3, BAU 43; 1, BAU 44; 2, BAU 50; 6, BAU 52; 5, BAU 55; 2, BAU 56; 4, JC 3.

DIAGNOSIS: Rostrum short, reaching to middle of visible part of first antennular article, tip curved upwards, anterior margin lateral to rostrum concave; dorsal carina high and thin ending abruptly at base of eyes. Orbital hoods inflated, projecting anteriorly as rounded vertical keel. Orbitorostral grooves broad and shallow, projecting anteriorly as flattened, rounded extensions of frontal margin.

Second article of antennular peduncle 2 times as long as wide and a little less than 2 times as long as visible part of first and third article. Stylocerite short with actue tooth not reaching end of first antennular article. Scaphocerite with outer margin slightly concave and with strong lateral tooth that reaches well beyond antennular peduncle, squamous portion narrow, reaching almost to end of antennular peduncle. Basicerite usually without lateral tooth.

Large chela sub-cylindrical, 2.2 times as long as wide with fingers occupying distal 0.3. Medial face moderately hirsute, lateral face glabrous. Dactylus heavy, varying from projecting at tip and crossing pollex when closed, to truncate and not crossing pollex. Merus stout, with outer face a little longer than broad. Superior margin slightly projected in a rounded tooth, inferointernal margin usually with subterminal tooth varying from rounded to broadly acute.

Small chelipeds usually sexually dimorphic. Typical chela of male stout, 2.6 times as long as broad with fingers and palm almost equal. Dactylus balaeniceps, fringe of hair more dense on medial margin with proximal broadening continuing for 0.8 of length then constricting; tip rounded and meeting, not overhanging, propodal tooth. Small chela of female slender, 3.4 times as long as broad, palm 1.3 times longer than dactylus and tapering from carpus to tip; fingers never balaeniceps. Carpus cup-shaped, 0.7 as long as palm. Merus 2.3 times as long as broad, inferointernal margin often bearing acute tooth distally.

Carpal articles of second leg with ratio: 10:20-30:6:6:10.

Ischium of third leg bearing spine. Merus 3.5 times as long as broad; inferior margin terminating in strong, acute tooth. Carpus almost half as long as merus, distoinferior margin terminating in an acute tooth similar to that of merus, distosuperior margin terminating in rounded projection. Propodus 0.6 as long as merus armed with 5 pairs of spines on the inferior margin and a pair distally. Dactylus simple, curved at tip.

Pleura of first abdominal somite of male not hooked.

Telson 2.2 times as long as posterior margin is broad, 1.4 times as broad anteriorly as posteriorly, anterior spines of dorsal pair placed well anterior to middle and posterior spines just posterior to middle. Posterior margin of telson with several small spines. Inner uropod bearing spines on lateral and distal margin.

DISCUSSION: The variability in this species was discussed by Banner (1957:201). The Australian specimens show the same variability. The basicerite is only occasionally armed; the distal end of the inferointernal margin of the merus of the large chela varies from a rounded tooth to a large acute tooth; the small chela is usually sexually dimorphic, but in some males the dactylus of the small chela is more slender, almost similar to that of the female. Finally the first and second article of the second leg varies from 10:20-30. Rathbun's specimen from Monte Bello Island can be encompassed in this range of variability and we are placing it in synonymy. This species is separated from some related species in Table 2.

We list Coutière's report of *A. crinitus* Dana as a synonym of *A. bucephalus* with some doubts. In his thesis in 1899 Coutière offered a drawing of a large cheliped that he labelled as *A. crinitus* (p. 266, fig. 273). In 1900 (p. 413) he listed *A. crinitus* as coming from the Torres Straits. In 1905, when he described *A. bucephalus* he cited his use of *A. crinitus* in 1899 under synonymy, but he made no mention there or later about the identity of the specimen from Torres Straits. He did not list the Torres Straits distribution under *A. bucephalus,* but neither did he list that locality under his rather comprehensive distributions given for 3 other species listed in the 1900 paper. De Man (1911:357), in discussing Ortmann's specimen of *A. crinitus* from Samoa and giving the published accounts of its distribution also ignored Coutière's record from the Torres Straits. Inasmuch as the two species are easily separated by the relative lengths of the first two articles of the carpus of the second legs, with the first article about one-third the second in *A. bucephalus* and with the two equal in *A. crinitus,* and inasmuch as in the extensive collections of *A. bucephalus* from Australia, including the Torres Straits, we had no specimen that could be identified as *A. crinitus*, we are presuming that Coutière had the two species as confused in 1900 as he had in 1899, and that his record was that of *A. bucephalus.*

BIOLOGICAL NOTES: This species has been collected at Enewetak (=Eniwetok) in the Marshall Islands as cohabiting pairs from tubes of "several types of algae and sponges" (B&B, 1968:284). It is discussed under the section on tube dwelling species on p. 93. This species has been collected intertidally from dead coral heads and as deep as 44 fathoms. The following colour notes were supplied by J. C. Yaldwyn from specimens from Heron Island, "Body and hands transparent with scattered green chromatophores. Gut dark green, ovaries and eggs bright green". It is not a large species, our largest specimen being 20 mm.

AUSTRALIAN DISTRIBUTION: In western Australia we have specimens from Cape Jaubert and Monte Bello Island; in northern Australia from the Torres Straits and the Gulf of Capentaria and in eastern Australia from off Port Douglas, Qld., south to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Off Africa from the Red Sea to Mozambique; across the Indian Ocean to Indonesia; in the Pacific from the Philippines and Japan eastward to the Line Islands and the Societies. It has not been reported from Hawaii.

DIADEMA GROUP

Oribital teeth usually lacking and orbital hoods at times projecting as vertical keels; base of rostrum at times flattened and sharply demarked from orbitorostral grooves; some species with teeth on anterior carapace. Large chela rounded to oval in section, usually with transverse groove proximal to dactylar articulation and lacking marked longitudinal grooves. Small chela of males at times balaeniceps. Third legs with or without tooth on merus, dactylus almost always simple. (Dactylus may be variable within a species — *cf. A. cristatus* Coutière and *A. diadema* Dana, below).

Most specimens of most species were collected intertidally to subtidally, although a few were dredged; many species are apparently confined to dead coral heads found in areas of clean water and moderate wave action.

Alpheus cristatus Coutière
Fig. 33

Alpheus cristatus Coutière, 1879b:303 (Thursday Is.) 1899:89, fig. 56.

SPECIMENS EXAMINED: 1 specimen from AM 228 (AM P. 27828); 1, AM 259 (AM P. 28116).

DIAGNOSIS: Rostrum narrow, acute, awl-shaped, reaching to end of first antennular article; rostrum carina compressed, rounded dorsally, continued posteriorly to merge with carapace at level of posterior portion of eyes. Midline carrying 2 forward-pointing teeth posterior to rostral carina, anterior tooth narrow, acute and overhanging; posterior tooth broader with rounded tip and continuing posteriorly as rounded crest to posterior third of carapace. Orbital hoods inflated and well-demarked on all margins except posterior; anteriorly with small but marked crest arising from upper anteromedial curvature of hood, overhanging curvature of hood and continued laterally and ventrally as definite curving crest that is finally confluent with outer margin of orbital tooth. Orbital teeth strong, acute, about one-third as long as rostrum, located somewhat medial to middle of eyes, separated from rostrum by concave margins. Surface of orbital teeth flattened and confluent with flattened orbitorostral area. Orbitorostral area broad anterior to eyes, narrow between eyes and again broadening posterior to eyes; posterolateral margin of area demarked by a narrow but overhanging crest, curving from behind orbital hoods towards base of anterior tooth of midline.

Visible part of the first antennular peduncle and second article almost equal, third article a little shorter; second article 1.6 times as long as broad. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with outer margin concave and with lateral tooth reaching about half length of third article past that article. Squamous portion just a little past end of antennular peduncle. Lateral tooth of basicerite prominent, acute, as long as stylocerite.

Large chela rounded in section and tapering towards fingers, 3 times as long as broad with fingers occupying the distal 0.3. Palm bearing a narrow, deep, transverse groove just proximal to dactylus not extending into either face. Superior margin of dactylus not strongly carinate. Merus 1.6 times as long as broad, Superior margin terminating in a heavy acute curving tooth. Inferoexternal margin lightly serrate, terminating distally in a

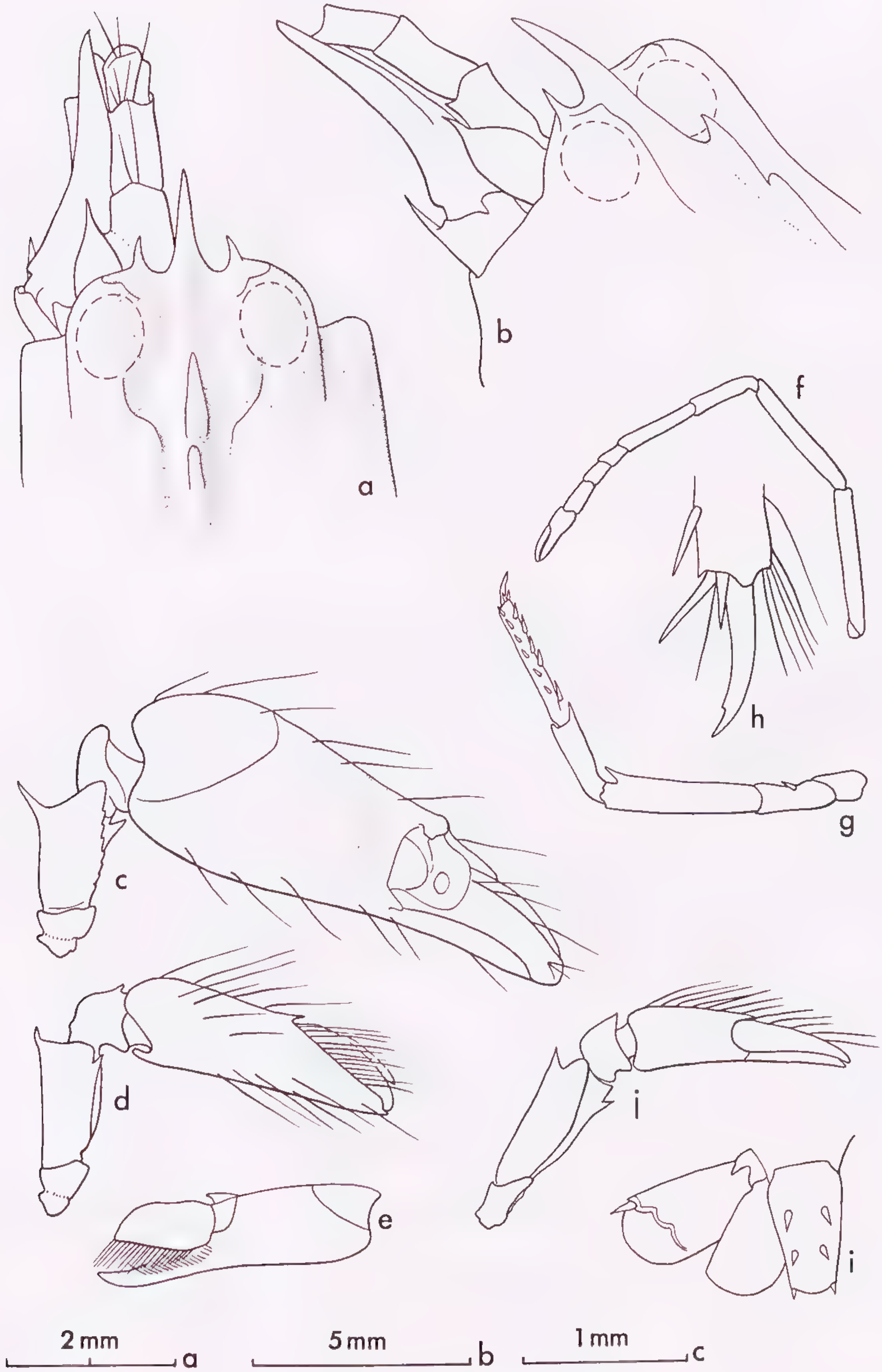

Fig. 33 *Alpheus cristatus* Coutière
24 mm male from AM 259. **a, b.** Anterior region, dorsal and dorsolateral view; **c.** large cheliped, lateral face; **d, e.** small cheliped, medial and chela, lateral face; **f.** second leg; **g, h.** third leg and enlarged dactylus; **i.** telson and uropods. 27 mm female from AM 228. **j.** Small cheliped. a, b scale a; c, d, e, f, g, i, j scale b; h, scale c.

rounded projection; distal end of inferointernal margin bearing an acute subterminal tooth.

Small chela sexually dimorphic. Male chela 3.5 times as long as broad with fingers occupying distal 0.3. Dactylus balaeniceps, superior surface broad, slightly constricted at articulation. Palm bearing at the articulation of dactylus an acute tooth medially and a low obtuse tooth laterally. Merus 2.3 times as long as broad with small acute tooth subterminally on inferointernal margin, superior margin terminating in a tooth smaller than that of large chela. Small chela of female more slender, not balaeniceps, fingers and palm subequal. Merus similar to that of male.

Carpal articles of second leg with ratio: 10:10:3:3:5.

Ischium of third leg bearing a spine; merus 5.3 times as long as wide with strong distal tooth on inferior margin. Carpus 0.4 as long as merus, inferior margin terminating in strong acute tooth, superior margin in a smaller subacute tooth. Propodus a little shorter than merus; inferior bearing 5 spines and a pair distally, lateral face bearing row of 6 smaller spines. Dactylus with a slight accessory tubercle on inferior margin.

Telson 2.6 times as long as posterior margin is wide. Transverse articulation of outer uropod scalloped.

DISCUSSION: We were able to examine the holotype at the Muséum National d'Histoire Naturelle in Paris and our specimens agree well with it. Coutière stated that except for the differences in the anterior region of the carapace, *A. cristatus* exactly resembled *A. bidens* (Olivier). He failed to note that *A. cristatus* lacks the slightest trace of a transverse groove on the superior margin of the palm of the small chela which is found in *A . bidens*. Further the carpus of the third leg in *A. cristatus* does not project into two terminal teeth on the inferior margin as it does in *A. bidens*. The holotype lacks any swelling on the inferior margins of the dactyus of the third leg, but this has been found to be variable in the related *A. diadema* Dana (p. 140).

BIOLOGICAL NOTES: Nothing is known of the ecology or colour of this species. Coutière does not mention where his specimens were collected, but one of our specimens was collected intertidally and the other was dredged from 3-5 fathoms. The larger of our specimens was 25 mm.

AUSTRALIAN DISTRIBUTION: One specimen was collected at Cape Leveque in western Australia and the other at Darwin in the Northern Territories. Coutière's original specimen was collected in the Torres Straits.

GENERAL DISTRIBUTION: Coutière also reported this species from the Maldives.

Alpheus bicostatus De Man
Fig. 34

Alpheus bicostatus De Man, 1908:102; 1911:375, fig. 82.

SPECIMENS EXAMINED: 1 specimen from AM 305 (AM P. 28117); 1, AM 324 (AM P. 28118); 1, WM 116-65.

DIAGNOSIS: Free portion of rostrum slender, awl-shaped, tip reaching slightly beyond end of first antennular article, with carina compressed, moderately high but rounded dorsally. Carina continued posteriorly with concave margins in regions of eyes and growing more confluent with carapace behind eyes; low carina interrupted in anterior gastric region by narrow rounded tubercle which continues as a low carina to

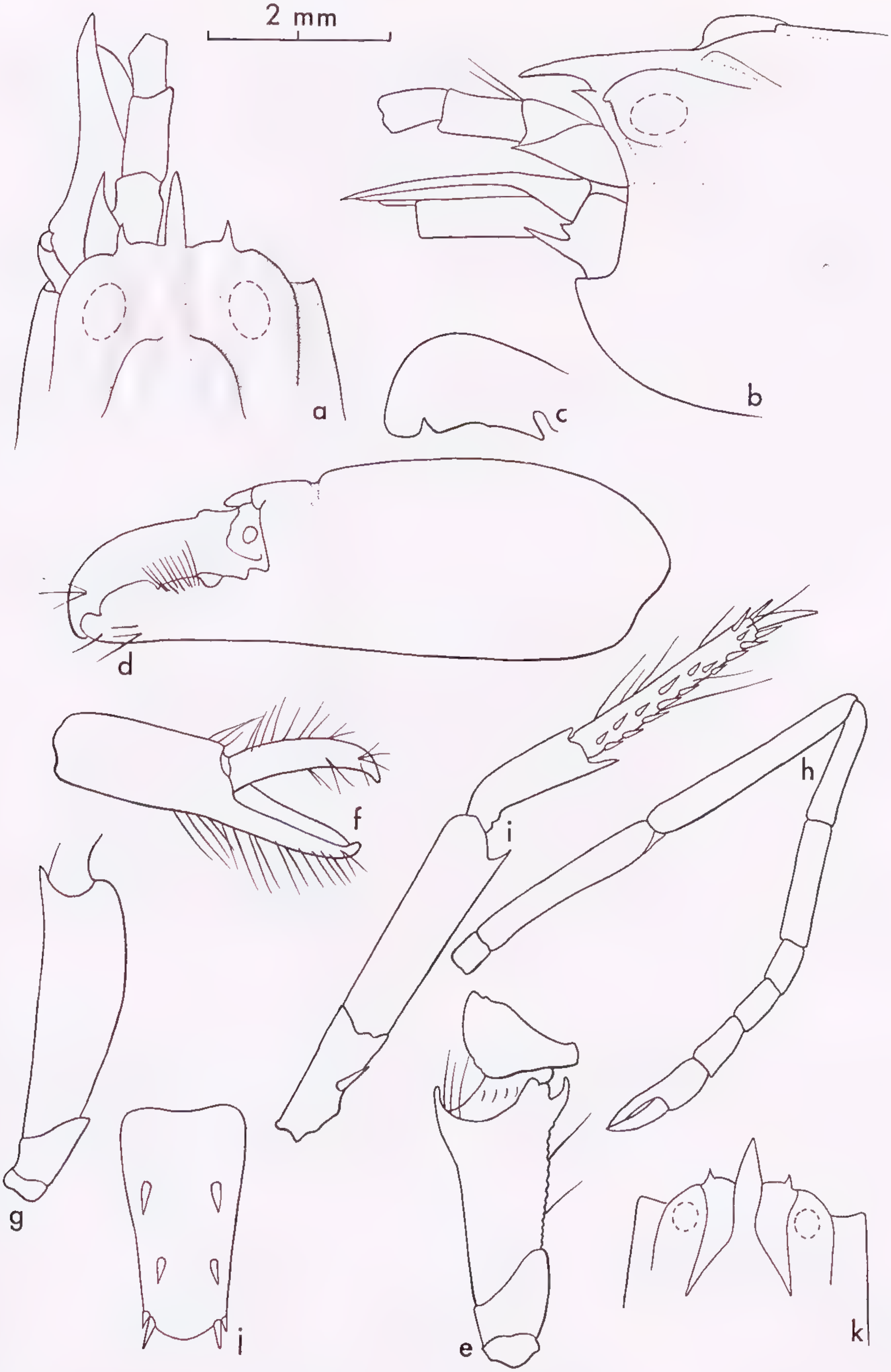

Fig. 34 *Alpheus bicostatus* De Man
19 mm female from AM 324. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and dactylus, lateral face; **e.** merus large cheliped, medial face; **f, g.** small chela and merus, lateral face; **h.** second leg; **i.** third leg; **j.** telson. 30 mm female from WM 116-65. **k.** Anterior region, dorsal view. All figures same scale.

midgastric region. Orbital hoods inflated, hemispherical, firmly demarked on anterior, medial and lateral magins and anteriorly projecting into a rounded, near vertical keel. Orbitorostral margin slightly arcuate, but almost at right angles to rostrum, bearing long setae and acute teeth laterally, with outer angle of teeth joining inner side of base of keel on orbital hoods. Orbitorostral area flattened between abrupt sides of rostrum and orbital hoods, broadening posteriorly behind eyes. Medioposterior margin of area terminated abruptly by curved and flattened crest, almost a narrow flap that overhangs area; near-horizontal crests arising near margins of rostrum and curving posterolaterally to terminate behind middle of eyes in anterior gastric region. Pterygostomial angle projecting, rounded and curving below basicerite.

Visible part of first and second antennular article nearly equal, third article a little shorter; second antennular article 2 times as long as broad. Stylocerite with slender tooth reaching just past end of first antennular article. Scaphocerite with outer margin concave, lateral tooth heavy, reaching well beyond antennular peduncle. Squamous portion narrow, reaching to end of antennular peduncle. Carpocerite reaching to middle of third antennular article. Prominent acute tooth on inferior margin of basicerite nearly as long as stylocerite; superior to this large tooth is a smaller subacute tooth.

Large chela subcylindrical, glabrous, 3 times as long as broad with fingers occupying distal 0.3. Superior margin of palm with narrow transverse groove proximal to dactylus continuing slightly into lateral and medial faces. Plunger of dactylus of minimal development. Merus 2 times as long as broad, bearing on superodistal margin a strong, acute and curved tooth. Inferointernal margin with small irregular teeth, without spines, but bearing subterminally a strong acute and curved tooth.

De Man (1911:377) reported the small chela as sexually dimorphic with that of male 3.8 times as long as broad with finger 0.4 total length; dactylus balaeniceps. Palm lacking transverse groove. Merus 2.5 times as long as broad with superior margin bearing tooth similar to that of large cheliped, but inferointernal margin unarmed. Small chela of female (our specimen) 4 times as long as broad, fingers and palm almost equal in length. Medial face of palm somewhat hirsute; lateral face glabrous. Fingers conical. Merus similar to that of male.

Ratio of carpal articles of second legs: 10:10:4:4:4.

Ischium of third leg bearing spine. Merus 4 times as long as broad, with acute tooth on distoinferior margin. Carpus 0.5 as long as merus. Inferior margin terminating in long acute tooth, superior margin terminating in a small rounded tooth. Propodus nearly as long as merus and bearing many spines on inferior margin and lateral face. Both inferior and superior margin bearing a pair of strong spines distally. Superior margin bearing a few long setae.

Telson 2.8 times as long as broad at posterior margin. Posterior margin strongly arcuate. Spines on superior surface prominent, anterior pair placed anterior to middle. Inner spines of posterolateral pairs nearly same size as dorsal spines.

DISCUSSION: Our specimens agree well with those described by De Man. However, we have one 30 mm female (WM 116-65) in which the rostral carina, instead of tapering uniformly, is markedly constricted near middle (fig. 34k). Since it agrees well with all other aspects of our specimens, we interpret this an an individual variation.

BIOLOGICAL NOTES: The specimen from Shark Bay was collected at 12 m. The others were collected intertidally. De Man's specimens were collected in a similar environment. Our largest specimen was 30 mm.

AUSTRALIAN DISTRIBUTION: One of our specimens was collected at Shark Bay in western Australia, another from the Torres Straits and the third from One Tree Island in the Capricorn Group in eastern Australia.

GENERAL DISTRIBUTION: Indonesia; Philippines.

Alpheus labis sp. nov.
Fig. 35

HOLOTYPE AND ONLY SPECIMEN: 17 mm male from Albany Passage area, Torres Straits, Qld. Collection by Melbourne Ward, Sept. 1928. AM 121 (AM P. 27234).

DIAGNOSIS: Rostrum triangular, as long as broad at base, not reaching beyond basal third of first antennular article. Rostrum without carina, anterior region of carapace smooth with slight orbitorostral grooves developed only near anterior margins. Visible part of first antennular article and second article equal, third 0.6 as long as second. Second article 1.7 times as long as broad. Stylocerite acute, not reaching end of first antennular article. Outer margin of scaphocerite straight, lateral tooth reaching just past end of second antennular article, squamous portion broad and reaching well beyond lateral tooth, carpocerite slightly longer than scaphocerite. Basicerite with acute, triangular tooth on its inferior margin.

Articles of third maxilliped: 10:2:4. All articles only slightly hirsute.

Large chela compressed, 3.4 times as broad (dorsoventrally) as thick laterally (measured at dactylar articulation), without notches or grooves, 3 times as long as broad, fingers occupying distal quarter. Palm 1.6 times wider than fingers when fingers are closed, plunger of dactylus well developed, of moderate length. Merus 3.2 times as long as broad, bearing on its inferointernal margin 2 small spines and strong, acute and curving subterminal tooth.

Small chela 6 times as long as broad. Palm 2 times as long as broad, fingers almost twice as long as palm, crossing at their tips and leaving fingers slightly agape. Fingers almost cylindrical with only a narrow cutting edge on opposing surfaces, bearing a few fine setae towards distal end. Carpus cup-shaped, 0.4 as long as palm. Merus slender, 9 times as long as broad, inermous.

Ratio of carpal articles of second legs: 10:7:3:3:4. All other thoracic legs missing.

Appendix masculina of endopod of second pleopod about half as long as adjacent *appendix interna*.

Telson 3 times as long as posterior margin is broad. Anterior margin 1.6 times wider than posterior portion, posterolateral pair of spines small, dorsal spines of normal development with anterior pair placed anterior to middle.

DISCUSSION: This species shows a relationship to both the Diadema and Brevirostris Groups. The compressed chela is found commonly in the latter group, but only a few species, such as *A. barbatus* Coutière, show compression to such a high degree. The extremely long fingers in relation to the palm of the small chela is found in such species as *A. rapax* Fabricius and *A. brevirostris* (Olivier). However, in the Brevirostris Group in general the large chela is usually more or less quadrangular in section, both chelae are almost never glabrous, but carry a fringe of setae at least along the margins, and those with long forceps-like development of the fingers of the small chela also carry dense rows of setae along the margins of the fingers. Often in the Brevirostris Group the third maxillipeds carry dense and long setae, the telson is broad

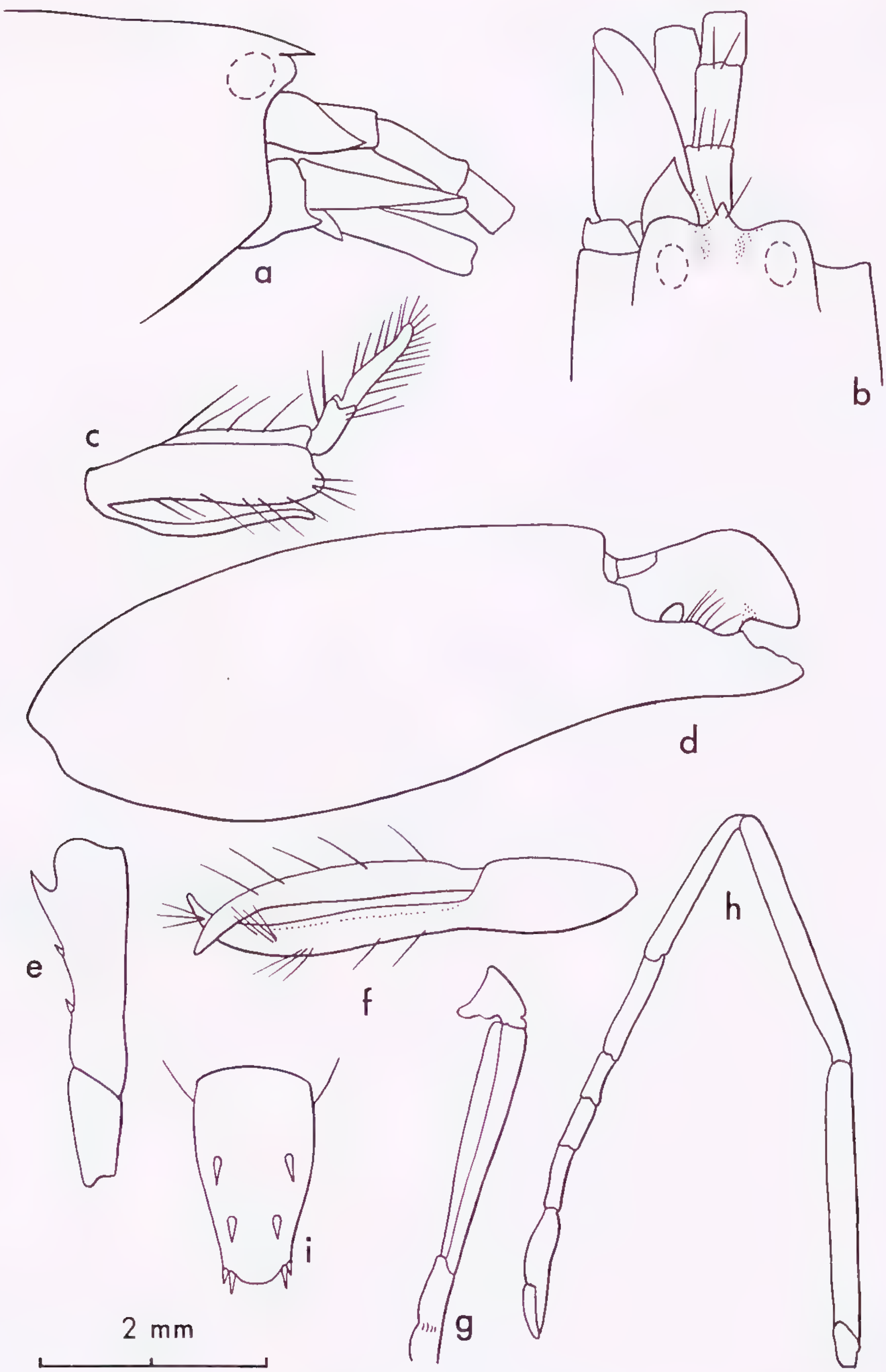

Fig. 35 *Alpheus labis* sp. nov.
Holotype (male) **a, b.** Anterior region, lateral and dorsal view; **c.** third maxilliped; **d, e.** large chela, lateral face and merus of large cheliped, medial face; **f, g.** small chela and merus, lateral face; **h.** second leg; **i.** telson. All figures same scale.

and with its tip projecting, and to our knowledge none have the almost complete lack of orbitorostral grooves.

This species is plainly different from all those in the Diadema Group that have deep orbitorostral grooves, with or without associated teeth such as *A. diadema* Dana or *A. bidens* (Olivier), and from those in which the large chela is more or less round in section. However, the species does resemble *A. paracrinitus* Miers in many ways: the form of the anterior carapace is quite similar, the lack of sculpturing on the large chela is the same (but it is only 1.4 times as broad as thick in *A. paracrinitus*); the armature of the merus of the large chela is almost identical, even the third maxillipeds, second legs and telson show similarities, but those are of rather generalized development. Other species in the Diadema Group showing some, but fewer, similarities are *A. mitis* Dana and *A. tenuipes* De Man. From all members of the Diadema Group this species may be differentiated by the development of the squame of the scaphocerite, the compression of the large chela and the proportions between the fingers and palm in that appendage and especially the long fingers of the small chela. We have decided to assign it to the Diadema Group because it shows none of the specialized adaptations for life on a muddy or silty bottom found usually in the Brevirostris Group; we suspect that the walking legs, when other specimens are found, will also show similar lack of adaptation.

Nothing is known of the habitat beyond the facts given on the label, reproduced above.

The name is derived from *labis*, Greek for forceps and refers to the form of the small chela. The holotype will be placed in the Australian Museum.

Alpheus paracrinitus Miers
Fig. 36

Alpheus paracrinitus Miers, 1881:365, pl. 16, fig. 6. Chace, 1962:609. Crosnier and Forest, 1966:253, fig. 15. Banner and Banner, 1967:278, 2 tbls.

Alpheus paracrinitus bengalensis Coutière, 1905a:901, pl. 82, fig. 37.

Alpheus bengalensis Holthuis, 1958:25.

Crangon paracrinita bengalensis Banner, 1953:110, fig. 40.

Crangon togatus Armstrong, 1940:2, fig. 1.

SPECIMENS EXAMINED: 1 specimen from AM 109 (AM P. 28119); 2, BAU 46.

DIAGNOSIS: Rostrum triangular, acute, somewhat longer than wide at base, tip almost reaching middle of visible part of first antennular article, rounded dorsally; base separated from anterior orbital hoods by short shallow and rounded depressions. Orbital hoods not inflated, rounded anteriorly. Orbitorostral margin only slightly concave. Second antennular article 2 times as long as wide, 1.5 times longer than third article. Tip of stylocerite reaching to end of first antennular article. Lateral spine of scaphocerite not reaching end of third antennular article, squame slightly shorter. Carpocerite reaching by length of third article past that article. Lateral spine of basicerite small but acute.

Large chela slightly compressed, without sculpturing except for a slight concavity on inferior margin in region of dactylar articulation. Chela 3 times as long as broad, fingers about 0.3 length of entire chela. Plunger of dactylus fully developed. Merus slender, 3.4 times as long as wide, armed with strong tooth on inferointernal margin slightly distal to middle, superodistal margin not projected.

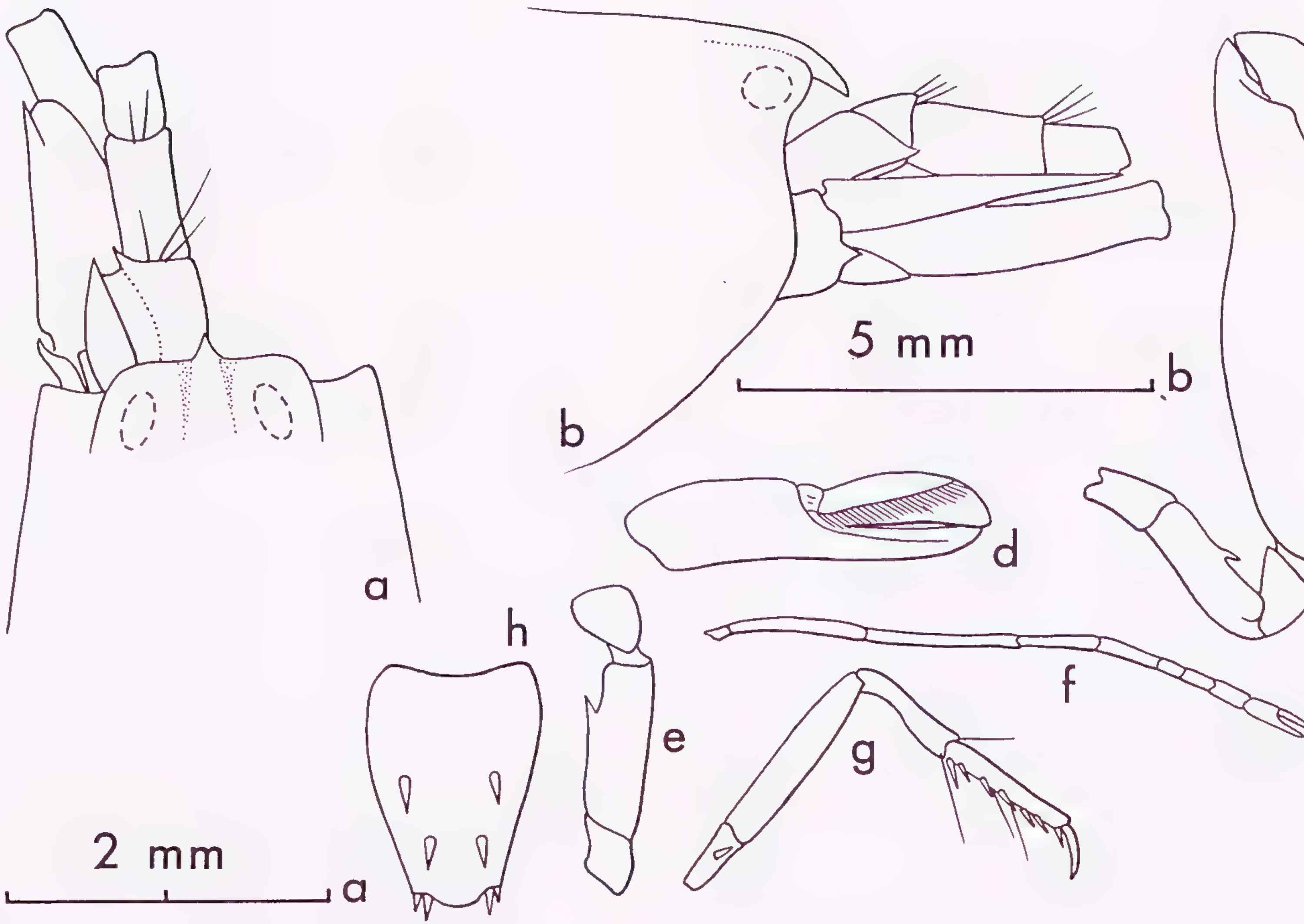

Fig. 36 *Alpheus paracrinitus* Miers
17 mm male from BAU 46. **a, b.** Anterior region, dorsal and lateral view; **c.** large cheliped, medial face; **d.** small chela, lateral face; **e.** merus, small cheliped, medial face; **f.** second leg; **g.** third leg; **h.** telson. a, b, h scale a; c, d, e, f, g scale b.

Small chela sexually dimorphic. Male chela 4.2 times as long as broad with fingers occupying half entire length, dactylus variable, at times balaeniceps. Female chela more slender, tapering. Meri in both sexes with spine on inferointernal margin similar to that of large chela.

Carpal articles of second legs with first and second article varying in relative lengths: 10:8-18:3:3:4. (From B&B, 1966b:116).

Ischium of third leg armed with small spine, merus 7 times as long as broad, inermous. Carpus half as long as merus, both distal margins projected but rounded. Propodus 0.7 as long as merus and armed with 6-8 movable spines on inferior margin. Dactylus simple, curved and elongate.

Telson 3 times as long as posterior margin is broad. Anterior pair of dorsal spines placed anterior to middle.

DISCUSSION: Miers type locality was Senegambia, West Africa; Coutière described the variety *bengalensis* from the Maldives in the Indian Ocean. Holthuis believed the Atlantic form was separate from that found in the Indo-Pacific and raised *A. bengalensis* to specific level; finally, Chace, comparing West African specimens to some from Clipperton Island, came to the conclusion that there was but a single circumtropical species without distinct characteristics that would warrant the separation of subspecies. Crosnier and Forest placed into synonymy *A. togatus* that Armstrong had described from Bermuda.

In 1967 we reviewed the extent of variation in our central Pacific collections which included over 200 specimens from the Cook and Society Islands alone, and found extensive variation in the armature of the large and small cheliped, and the degree of balaeniceps development on the small chela of the male in the ratio of the first two carpal articles of the second leg, and in the carpal-propodal length ratio of the third legs. As these characteristics were those that were supposed to separate the two subspecies or species, we confirmed Chace's conclusion. We have examined the type of *A. togatus* at the American Museum of Natural History in New York and agree with the action of Crosnier and Forest.

BIOLOGICAL NOTES: The species apparently is confined to the intertidal and the upper subtidal with the greatest depth reported to be 18 m; it occurs under boulders in dead coral heads and in coralline algae. Miya (1974:159) reported that it has also been found from heads of *Tubipora*.

No one has published colour notes on the species, but our notes made in Hawaii showed that the entire specimen was transparent white with transverse bright red bands. The bands were broad and diffuse on the large and small chelae, slight on the anterior carapace, more defined but confined to the middle on the posterior carapace, and narrow and well-defined on each abdominal segment, running from pleuron to pleuron; both the antennular bases and the tip of the telson and uropods were splashed with red stellate chromatophores. We have observed similar colouration in other parts of the Pacific.

The largest specimen we have seen was 20 mm in length.

AUSTRALIAN DISTRIBUTION: Only 3 specimens have been collected, one from the Herald Cay in the Coral Sea and 2 from Heron Island on the Great Barrier Reef; considering how common it has been found to be in the central Pacific, it is surprising that more specimens have not been collected in Australian waters.

GENERAL DISTRIBUTION: As indicated, the species appears to be circumtropical, in the Indo-Pacific running from the Red Sea through the Hawaiian and Society Islands to Clipperton Island lying west of Central America; from the Ryukyus in the north to the Capricorn Group in the south; in the Atlantic from the Gulf of Mexico and the Caribbean to West Africa.

Alpheus ehlersii De Man

Fig. 37

*Alpheus ehlersii** De Man, 1909c:663, pl. 70. Banner and Banner, 1966b:114, fig. 40.

Alpheus macrochirus De Man, 1888a:519. (*Nec* Richters, 1880).

SPECIMENS EXAMINED: 1 specimen from BAU 16; 1, BAU 20; 7, BAU 29; 1, BAU 43; 2, BAU 44.

DIAGNOSIS: Rostrum acute, reaching well past middle of visible part of first antennular article. Rostral carina rounded, reaching to posterior margin of slightly inflated orbital hoods, orbitorostral grooves not pronounced. Orbitorostral margin bearing slight arcuate prominences. Visible part of first antennular article and second article equal, second article almost 2 times as long as broad, and 1.5 times as long as third article. Stylocerite acute, reaching past end of first antennular article. Lateral tooth of scaphocerite reaching to end of antennular peduncle, somewhat longer than narrow squamous portion and turned inward at tip. Carpocerite reaching beyond end of antennular peduncles. Basicerite with strong tooth.

Large chela slightly compressed, 2.7 times as long as broad, fingers not quite 0.3 of total length; superior margin proximal to dactylus bearing shallow transverse groove that extends obliquely toward medial face; groove so faint that chela often must be rotated to discern it; inferior margin bearing slight constriction opposite articulation of dactylus. Plunger of dactylus well developed. Merus 2.2 times as long as broad with inferointernal margin armed with 6-9 spines and bearing acute tooth distally. Superior margin not projecting. Merus of female more slender, but with similar armature.

Small chelipeds not sexually dimorphic, chela 4 times as long as broad with fingers a little longer than palm; rounded tooth on medial side of dactylar articulation. Merus 2.6 times as long as broad, bearing several small spines on inferointernal margin and distally a rounded tooth.

Carpal articles of second leg with ratio: 10:5:2:2:4.

Ischium of third and fourth legs with spine. Merus of third leg inermous, 4.3 times as long as broad. Carpus 0.6 as long as merus, superior margin projected into a rounded distal tooth, inferior margin truncate distally. Propodus 0.7 as long as merus, bearing on its inferior margin 5 spines and a pair distally. Dactylus simple, 0.3 as long as propodus.

Telson 2.5 times as long as posterior margin is broad. Anterior pair of dorsal spines placed just anterior to middle. Inner spines of posterolateral pair the same size as dorsal spines.

DISCUSSION: The holotype of this species is apparently missing so we were unable

*Spelled *ehlersi* according to the International Code of Zoological Nomenclature of 1961; *ehlersii* by the code of 1964, but not again changed in the revisions of 1974. These changes in rules have also been applied to the names *Synalpheus stimpsonii* (B&B, 1975:292) and *Alpheus edwardsii* (p. 404) Rule 32 (a)(ii) also requires that *Athanas haswelli* Coutière as used by Hale, 1927:47 and B&B, 1973:316 be returned to its original spelling of *A. hasswelli.*

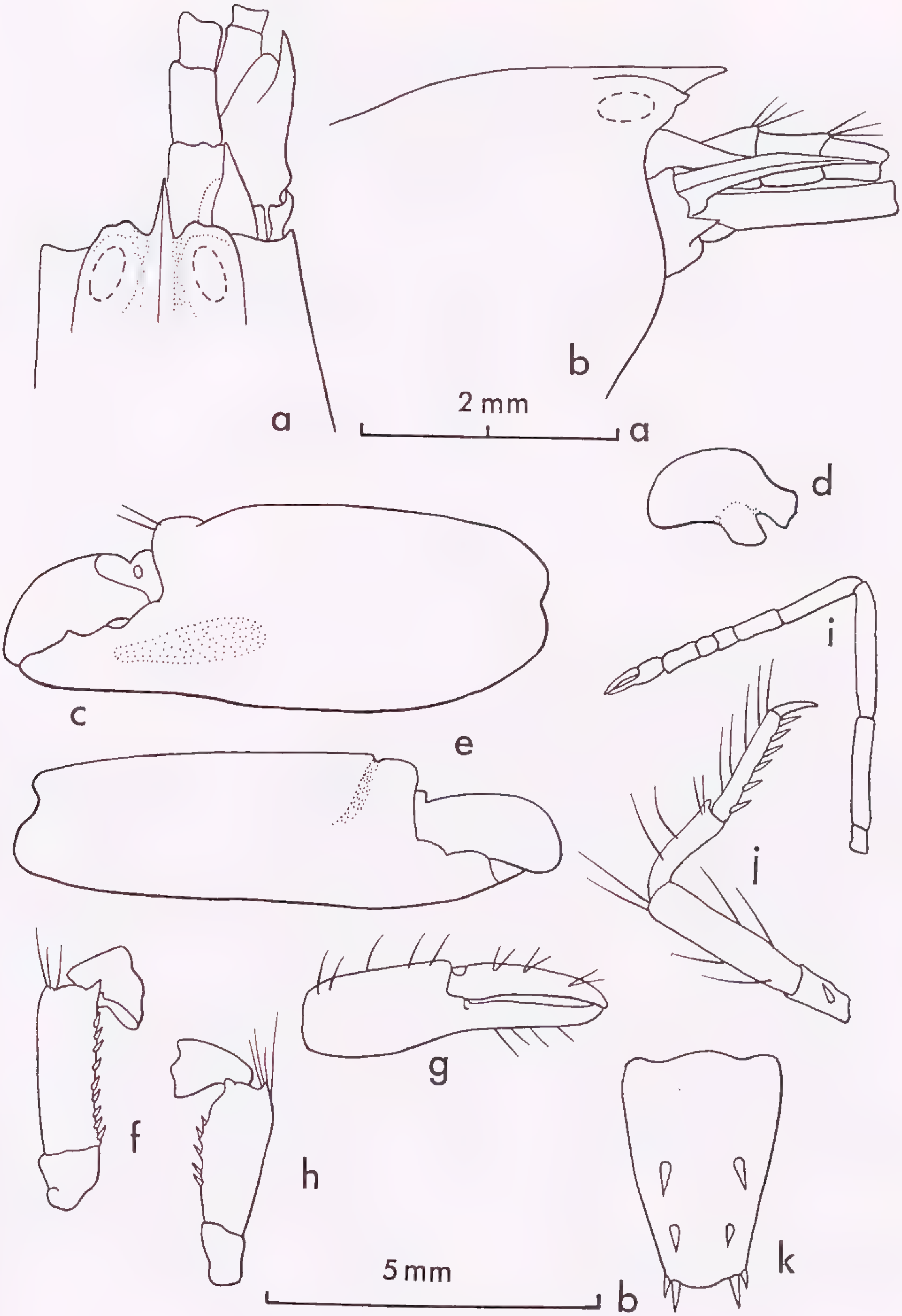

Fig. 37 *Alpheus ehlersii* De Man
17 mm male from BAU 29. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and dactylus, lateral face; **e.** large chela, superomedial face; **f.** merus, large cheliped, medial face; **g.** small chela, lateral face; **h.** merus, small chela, medial face; **i.** second leg; **j.** third leg; **k.** telson. a, b, k scale a; c, d, e, f, g, h, i, j, scale b.

to compare our specimens with it. The anterior portion of this species is somewhat variable. The rostrum in some specimens reaches to the end of the first antennular article. The lateral tooth of the scaphocerite often extends much beyond the antennular peduncle and the carpocerite is sometimes as long as the third antennular article past that article. The lateral margins of the telson on the Australian specimens, as well as those from Thailand, are almost straight not having the broadly curved margins with the marked constriction posteriorly as was figured for the type.

BIOLOGICAL NOTES: This species has been collected intertidally from heads of dead coral. We made the following colour notes on the specimen from BAU 43. "With 2 longitudinal brown bands separated mid-dorsally by pinkish band, chelae more or less with a continuation of the brown band. Tail fan dark at base then with light band and terminating in dark band." It is not a large species with our largest specimen being 17 mm.

AUSTRALIAN DISTRIBUTION: We have specimens from Rudder Reef near Port Douglas to as far south as Hayman Island in central Queensland.

GENERAL DISTRIBUTION: Eylat, Israel; Bay of Djakarta; Philippines; Thailand; Tonga; Samoa; Marshall Is.; Phoenix Group.

Alpheus mitis Dana
Fig. 38

Alpheus mitis Dana 1852:549, pl. 35, fig. 1.

SPECIMEN EXAMINED: 1 specimen from BAU 58.

DIAGNOSIS: Rostrum acute, almost twice as long as broad at base with a rounded carina that extends posteriorly to base of eyes. Orbital margins rounded, slightly concave at base of rostrum, orbitorostral grooves shallow. Visible part of first and second antennular article subequal, second article almost 2 times as long as broad; third article 0.6 as long as second. Stylocerite acute reaching just past end of first antennular article. Scaphocerite with outer margin slightly concave, lateral tooth strong, reaching past end of antennular peduncle, squamous portion reaching to middle of third antennular article. Carpocerite reaching length of third article past that article, basicerite with small acute tooth.

Ratio of articles of third maxilliped 10:3:6. Third article with tip bluntly rounded, bearing only several long setae.

Large chela smooth, 4.1 times as long as broad with fingers and palm almost equal, bearing only a few sparsely placed setae. Carpus somewhat elongate, about one-third length of merus, merus 3.3 times as long as broad, bearing a small acute tooth distally on inferointernal margin.

Small chela 4.1 times as long as broad, fingers a little longer than broad, dactylus conical. Merus 3 times as long as broad bearing an acute tooth distally on inferior margin, superior margin rounded.

(Small chela lacking in Australian specimen, description and figure of 10 mm male from the Philippines).

Ischium of third leg bearing an acute spine. Merus 5.0 times as long as broad, inermous. Carpus 0.5 as long as merus, distoinferior margin rounded; distosuperior margin terminating in small obtuse projection. Propodus 0.7 as long as merus, bearing 5-6

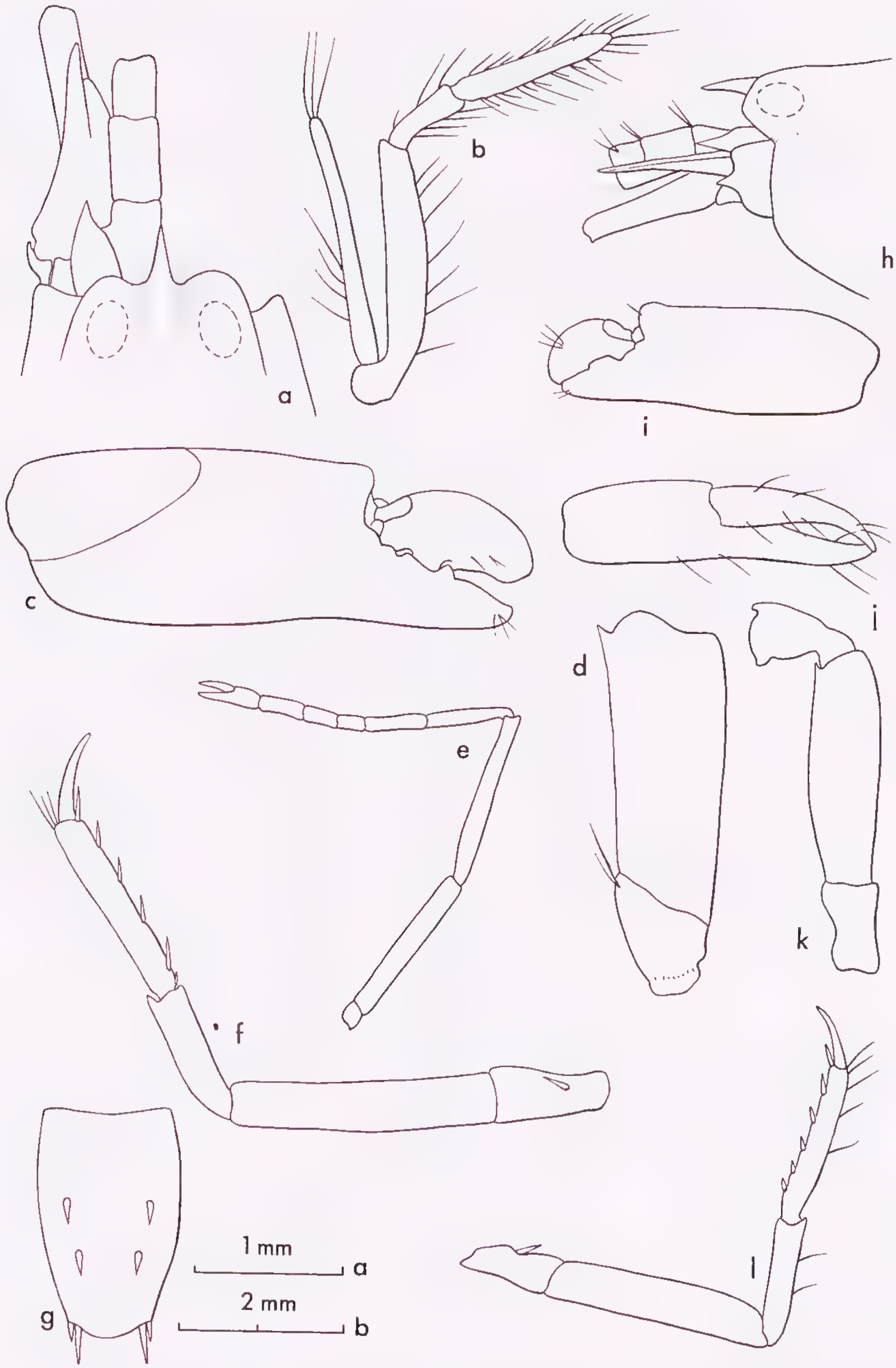

Fig. 38 *Alpheus mitis* Dana
14 mm male from BAU 58. **a.** Anterior region, dorsal view; **b.** third maxilliped; **c, d.** large chela, lateral face and merus medial face; **e.** second leg; **f.** third leg; **g.** telson. 10 mm male from Zamboanga, Mindanao, Philippines. **h.** Anterior region, lateral view; **i.** large chela, medial face; **j, k.** small chela, lateral face and merus medial face; **l.** third leg. a, b, c, d, e, f, g, h, j, k, l scale a; i scale b.

spines and one distally. Dactylus simple, slender, 0.4 as long as propodus.

Telson 2.5 times as long as posterior margin is broad; inner spines of posterolateral pairs with length equal to half breadth of tip and over twice as long as outer pair.

DISCUSSION: In addition to the single 14 mm male from Australia, we have in our present collections two specimens from Madagascar, the larger being 15 mm long, and one 10 mm male from near Zamboanga in the southern Philippines. Inasmuch as the species is little known, being recorded only twice since its original descripton by Dana (Nobili, 1907:355, Sendler, 1923:46, both from the Tuamotus), and inasmuch as the Philippine specimen was collected only about 600 km away from the type locality, the Balabac Straits, we have decided to use this paper for reconsideration of the species. Unfortunately, all specimens are smaller than Dana's which was 9 lines, or about 19 mm long. There are some slight differences in relative proportions: In the Australian specimen the rostrum reaches only to the final third of the first antennular article instead of to the end and the stylocerite reaches only to the end of the article instead of clearly surpassing it. The carpocerite reaches beyond the end of the antennular peduncles almost by the length of the third article, and the lateral spine of the scaphocerite is approximately equal to the antennular peduncle, while in Dana's figure the conditions are reversed with the carpocerite being equal and the scaphocerite markedly longer. The chelae in our specimens are slender, the larger being 2.5 times as long as broad and the smaller chela 4.1 instead of 2.5 and 3.2 times, respectively (from plate). Finally, the merus of the third leg is heavier, 4.5 times as long as broad in this specimen and 5.0 in Dana (from plate). However, as these proportions differ in the other specimens and may also reflect maturity of the specimens we do not attach great significance to the differences. It is interesting to note that all 4 specimens had the long inner spines on the posterolateral margins of the telson.

AUSTRALIAN DISTRIBUTION: This specimen, the only one known from Australia, came from a small pocket on the reef flat at Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Madagascar; Southern Philippines and Tuamotus.

Alpheus bidens (Olivier)
Fig. 39

Palaemon bidens Olivier, 1811:663.

Alpheus bidens Milne-Edwards, 1837:353, pl. 24, fig. 11, 12. Coutière. 1899: figs. 57, 274. De Man, 1911:371, fig. 80. Banner, 1957:203.

Alpheus tridentatus Zehntner, 1894:204, pl. 8, fig. 24.

Alpheus praedator De Man, 1908:103, 1911:373, fig. 81.

Alpheus dissodontonotus Stebbing, 1915:83, pl. 86.

Previous Australian Records
Olivier, 1811:663. New Holland.
Hale, 1927a:47; 1927b:308. South Australia (as *Crangon praedator*)
McNeill, 1968:16. Near Low Isles, Great Barrier Reef.

SPECIMENS EXAMINED: 1 specimen from AM P. 2349; 1, AM P. 10837; 1, AM P. 13509; 1, BAU 11; 2, BAU 20; 2, BAU 43; 2 BAU 48; 1, SM 3; 3, SM C-514; 2, SM C-515; 1, VM 32; 1, WM 31-65; 2, 75 LIZ-8 (AM P. 27913).

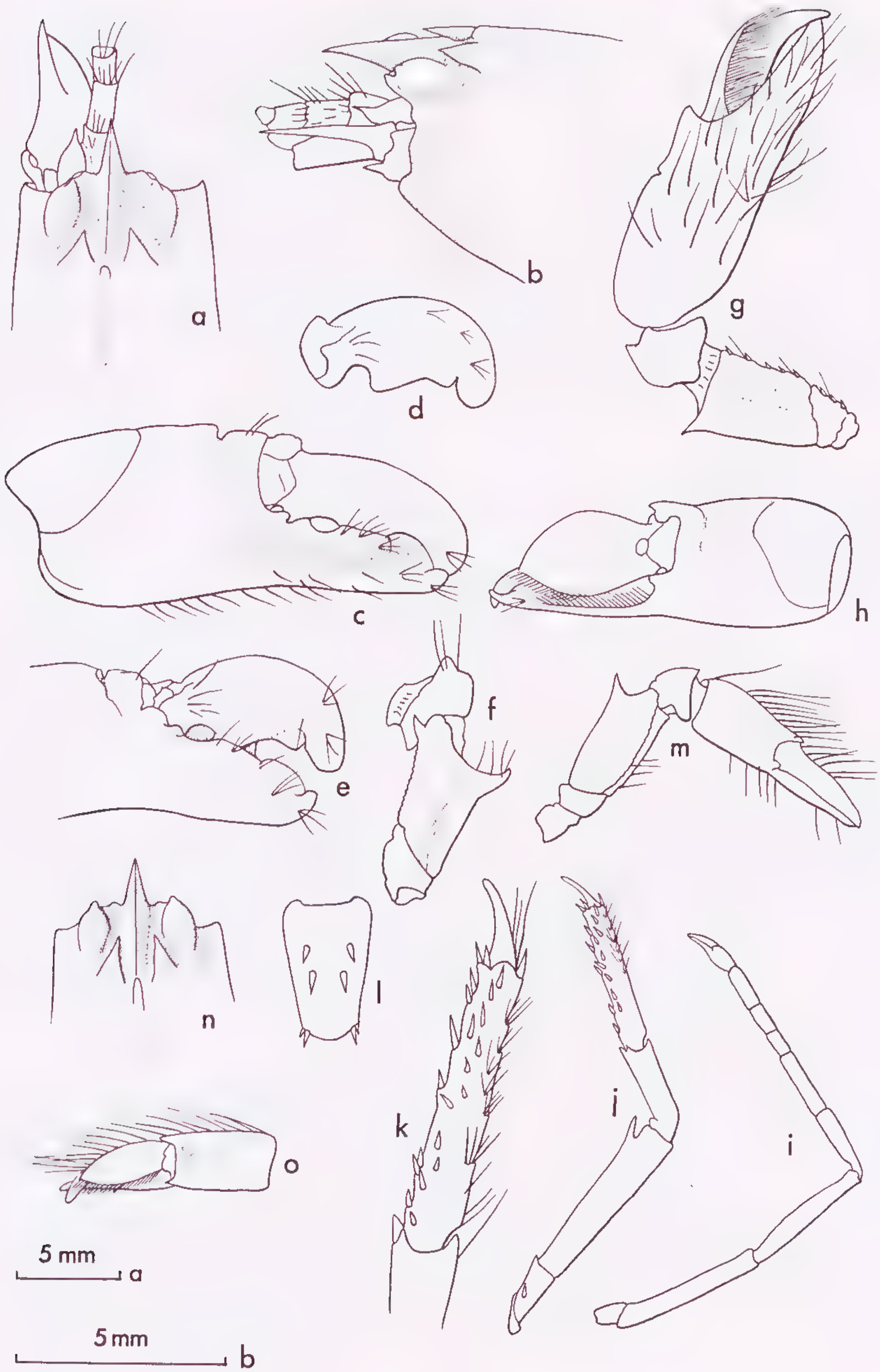

Fig. 39 *Alpheus bidens* (Olivier)
55 mm male from WM 31-65. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and dactylus, lateral face; **e.** distal region of large chela, lateral face; **f.** merus of large cheliped, medial face; **g.** small cheliped, medial face; **h.** small chela, lateral face; **i.** second leg; **j, k.** third leg and enlarged propodus and dactylus, lateral face; **l.** telson. 47 mm female from AM P. 10837. **m.** Small cheliped, lateral face. 48 mm male from SM C 517. **n.** Anterior region of carapace, dorsal view; **o.** small chela, superior face. a, b, c, d, e, f, g, h, i, j, l, m, n, o scale a; k scale b.

DIAGNOSIS: Rostrum narrowly triangular, acute, reaching to or beyond end of first antennular article; high and sharp rostral crest reaching from tip to level of posterior end of orbital hoods. Posterior to rostral crest lies a small flattened area followed by a second dorsal carina, anteriorly somewhat rounded and overhanging flattened area, laterally rounded and posteriorly merging with carapace in gastric region. Orbital hoods hemispheric in section; in dorsal view elongate, oval, almost egg-shaped, with middle to anterior portion abruptly set off from surrounding carapace and with anterior margin bearing definite keel which becomes confluent with orbitorostral margin. Orbitorostral margin convex; orbitorostral area depressed and slightly concave. A pair of acute triangular dorsal teeth arising near level of anterior end of posterior dorsal carina with tips reaching slightly posterior to middle of orbital hoods; these thin, flat teeth are slightly rounded to curvature of carapace and overhang orbitorostral depressions.

Visible part of first antennular article and second article nearly equal, second article 1.3 times as long as broad; third article a little shorter than second. Distal margins of antennular articles bearing stiff setae. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with outer margin concave, with strong lateral tooth directed inward at its tip; squamous portion narrow, reaching just beyond end of antennular peduncle. Carpocerite reaching middle of third antennular article. Basicerite with strong acute lateral tooth.

Large chela nearly cylindrical in section 2.6 times as long as broad with fingers occupying distal 0.4. Dactylar articulation at about 90° angle to axis of body flanked by heavy, blunt teeth. Superior margin of palm, with narrow deep transverse groove curving on lateral face toward dactylar articulation, but continuing only a short distance into medial face. Medial face of chela bearing stiff forward directed setae. Lateral face glabrous and bearing a very slight rounded longitudinal depression on inferior portion of lateral face of palm starting near level of transverse articulation and continuing past socket of pollex. Dactylus thickened with broad carina on superior surface. Both fingers with oppositive faces distal to plunger and socket developed into thin knife-like shearing teeth that cross when fingers are closed. Plunger of minimal development. Merus 1.5 times as long as broad; superodistal margin strongly projected into a subacute tooth; inferointernal margin minutely dentate and bearing a few small spines, and terminating in strong tooth. Superoexternal margin also minutely dentate. Medial face of merus with longitudinal groove.

Small chela sexually dimorphic. Male chela with balaeniceps dactylus, 2.8 times as long as broad with fingers and palm almost equal. Superior surface of dactylus with broad triangle which is 1.5 times as long as broad at its widest point. Outer margins of triangle with continuous fringe of thick, short, stiff setae. Pollex also bearing upward directed crest of hair on both faces that continues distally to distal quarter of pollex. Dactylar articulation flanked by heavy blunt teeth. Superior surface proximal to dactylus bearing transverse groove similar to large chela. Medial face of palm hirsute, lateral glabrous. Merus 1.7 times as long as broad; superodistal angle projecting as a strong inwardly curving subacute tooth; inferointernal margin bearing short heavy spines and an occasional seta, without distal tooth. Medial face bearing longitudinal groove near inferolateral margin. Small chela of female 3.4 times as long as broad, fingers and palm equal, fingers simple and tapering, palm without sculpture, medial surface hirsute, lateral surface glabrous. Merus similar to that of male.

Ratio of carpal articles of second leg: 10:10:3:3:6.

Ischium of third leg with spine. Merus 4.5 times as long as broad; inferior margin bearing acute subterminal tooth. Carpus 0.5 as long as merus, superior margin

terminating in subacute tooth; inferior margin terminating in 2 subacute teeth. Propodus 0.8 as long as merus bearing on its inferior margin 7 spines with a pair distally, and many randomly placed smaller spines. Superior margin bearing setae set in clusters of 2 to 4 and one distal spine. Dactylus simple and 0.2 as long as propodus.

Telson 2.2 times as long as posterior margin is broad. Anterior pair of dorsal spines placed anterior to middle, inner spines of posterolateral pair equal in size to dorsal spines.

DISCUSSION: In 1811 Olivier described this species based on a specimen collected by Péron from "Nouvelle-Hollande" and Péron's collections could have been made anywhere from Sydney around the southern, western and northern coasts of Melville Island, near Darwin (see p. 52). We have been able to examine the holotype in the Muséum National d'Histoire Naturelle in Paris. In it the large chela is missing, but it was figured by Milne-Edwards.

In 1908 and 1911 De Man described a species he called *A. praedator* from Ambon in Indonesia, which he separated from the specimens he identified from the Siboga Expedition as *A. bidens* by three characteristics: 1. the interorbital portion of the rostral carina was higher and sharper in *A. praedator* than in *A. bidens;* 2. the portion of the crest posterior to the post-orbital tubercle was prolonged into a demarked crest running to the posterior third of the carapace in *A. praedator* instead of being higher anteriorly and fading more abruptly into the carapace in *A. bidens;* 3. the transverse groove proximal to the dactylus of the large chela extended to the lateral (or lower) face of the palm where it continued as a broad shallow depression in *A. praedator* while in *A. bidens* the groove was not continued onto the lateral face.

We were able to examine the holotype of *A. praedator* and 18 specimens De Man had identified as *A. bidens* from the Siboga Expedition at the Zoologisch Museum in Amsterdam. Of the 20 specimens in the present study collection as well as De Man's 18 specimens these three characteristics are variable, with the form of the anterior and posterior portions of the dorsal carina varying from that described by De Man as the *bidens*-condition to that approaching but not reaching the development found in De Man's holotype. It should be noted in passing that the holotype for *A. bidens* was also intermediate between the two extremes discussed by De Man. The large chela of Olivier's type was drawn by Coutière (1899: fig. 274), and its development was accurately described by De Man and found in the 2 of his 18 specimens that at present have the chela present. The Australian specimens in the present collection again are variable, but most have a depression in the lateral face of the palm, similar to *A. praedator.*

There remains one difference between the Australian forms and those from Indonesia: neither Olivier's type nor any of the present collection bear teeth on the distal margin of the first antennular article, but rather they carry short, stiff setae, while all of De Man's specimens under both names had 2 teeth at the end of this article. We regard this difference as rather insignificant, probably even at the subspecies level, and therefore, in view of the variation remarked upon above, place *A. praedator* into synonymy under *A. bidens.*

Stebbing described a new species from South Africa, *A. dissodontonotus* (1915:83) which he regarded as close to *A. bidens*. The first characteristic he used to separate the two was the dorsal carina which we have found to be variable. The second characteristic he gave was the presence of an "anterior tubercle" on the eye hoods, which apparently is the anterior keel found on the hoods in all specimens we have examined. The third difference was the length relationship between the visible portion of the first and second

antennular articles, but this will vary in any specimen within the limits of his differences by the angle that the first article makes to the carapace in death. Finally, he stated that the first carpal article of the second leg was "decidedly longer than the second" and showed it in his figure to be 1.2 times as long, and in the present series the first article is 1.0 to 1.4 times the length of the second. The figures he gives for his species are easily within the range we have found for the Australian specimens, so this species, too, we are placing in synonymy.

In one of our specimens (SM C-517) the usual acute teeth on the carapace at the base of the eyes are placed much further forward, reaching about the middle of the orbits. The small chela is also more slender, being 3.4 times as long as broad instead of 2.8 as in our specimens. In all other ways it is the same as our other specimens. We feel this is probably an individual variation.

BIOLOGICAL NOTES: All of the Australian specimens were collected intertidally with the exception of the specimen from SM C-517 which was collected at 24 m. The specimens of *A. bidens* from the Siboga Expedition were dredged as deep as 83 m. The species was collected in the Marshall Islands from heads of the coral *Stylophora mordax* (Banner, 1957:203; B&B, 1968:287). Olivier described his type as *"La couleur de ce crustacé, conservé dans l'eau-de-vie, est d'un rouge tres-pâle, avec trois taches blanches, grandes & ovales sur chaque anneau de la queue"*. Our field notes indicate for a pair from Heron Island (BAU 48) "Chela pale pink, small chela, pale pink, fingers brown. Abdomen with uneven stripes of brown and pale pink. Antennae with pink and brown stripes". Our specimens range in size up to 58 mm. However, Hale (1927a:47) mentions specimens as long as 67 mm; Olivier's type was 77 mm in length.

AUSTRALIAN DISTRIBUTION: The collections extend from Lizard Island in northern Queensland to Heron Island in the Capricorn Group; also in Victoria, Melbourne and Tasmania; one specimen came from near Perth in western Australia.

GENERAL DISTRIBUTION: Indonesia; *"mers d'Asie"* (Milne-Edwards, *loc. cit.*); Ryukyus; Marshall Islands.

Alpheus diadema Dana

Fig. 40

Alpheus diadema Dana, 1852:555, pl. 35, fig. 7.

Alpheus insignis Heller, 1861:269, pl. 3, fig. 17, 18.

Crangon diadema Banner, 1953:118, fig. 43 [Neotype established].

Previous Australian records:
McNeill, 1968:16. Low Isles, Qld.
?Nobili, 1899:233. Beagle Bay, W.A. [as *A. insignis*].

SPECIMENS EXAMINED: 1 specimen from AM 74 (AM P. 27471); 1, AM 109 (AM P. 27509); 1, AM 123 (AM P. 27320); 2, AM 186 (AM P. 27321); 5, AM 283 (AM P. 27322); 5, AM 324 (AM P. 27357); 1, AM 335 (AM P. 27358); 1, AM 336 (AM P. 27359); 2, AM 340 (AM P. 27360); 1, AM P. 27434; 1, AM P. 27436; 1, BAU 10; 1, BAU 11; 1, BAU 20; 1, BAU 29; 1, BAU 32; 1, BAU 43; 1, BAU 48; 2, BAU 53; 2, BAU 54; 2, BAU 55.

DIAGNOSIS: Rostrum variable, usually short, reaching to middle of visible portion of first antennular article; rostral crest on carapace broad, reaching posterior to orbital

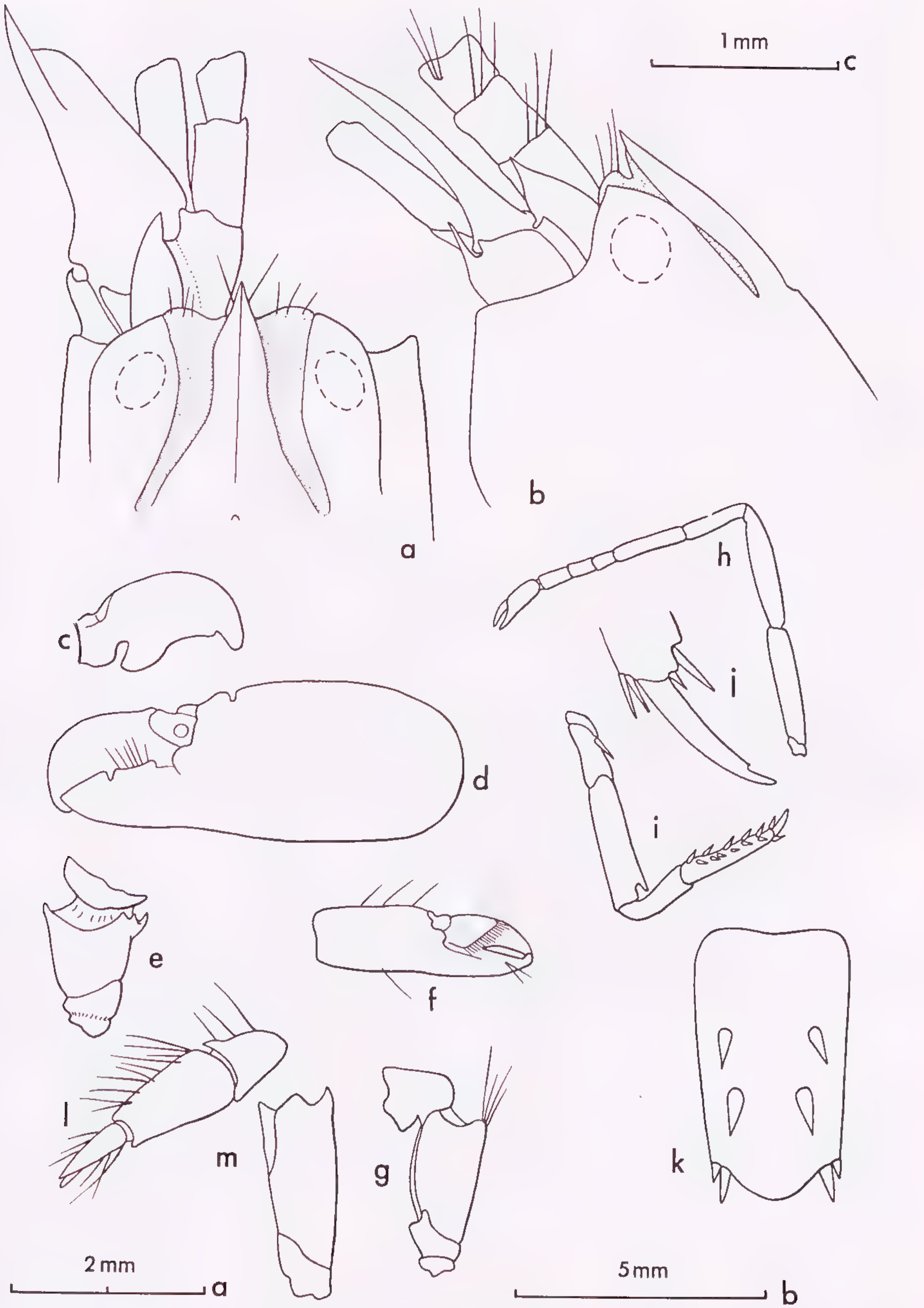

Fig. 40 *Alpheus diadema* Dana
19 mm male from BAU 54. **a, b.** Anterior region, dorsal and lateral view; **c.** dactylus of large chela, medial face; **d.** large chela, lateral face; **e.** merus of large cheliped, medial face; **f, g.** small chela, lateral face and merus medial face; **h.** second leg; **i, j.** third leg and enlarged dactylus; **k.** telson. 27 mm. female from BAU 54. **l, m.** Small chela, superior face and merus lateral face. a, b, k scale a; c, d, e, f, g, h, i, l, m scale b; j, scale c.

hoods, with margins anterior to eyes tapering to acute tip, middle portion in region of eyes with sides almost parallel, and posterior portion rapidly broadening; dorsal surface with carina prominent only in middle section, and midline carrying slight protuberance at posterior limit of rostrum. Rostral margins overhanging flattened orbitorostral grooves, in posterior sections almost meeting corresponding overhanging ridge on orbital hoods. Anterior orbitorostral margins convex and reaching beyond orbital hoods. Orbital hoods high, rounded, conspicuously demarked on all sides and anteriorly projecting as slight, rounded vertical keel.

Antennular peduncle with visible part of first and second article almost equal in length; third article shorter; second article almost twice as long as broad. Stylocerite short and broad, lateral spine reaching to end of first antennular article. Scaphocerite with outer margin concave, with strong lateral tooth reaching well beyond antennular peduncle; squamous portion reduced, reaching to end of antennular peduncle. Carpocerite reaching to end of antennular peduncle. Lateral spine of basicerite prominent, reaching as far forward as rostum.

Large chela subcylindrical, almost as broad as high, about 3 times as long as broad, tapering distally; surface without sculpture except for transverse groove proximal to articulation of dactylus. Chela sparsely hirsute on upper and medial surfaces. Dactylus about 0.4 length of chela, strong, with superior margin arcuate. Plunger of dactylus moderately long. Merus 0.6 as long as broad, about a quarter as long as chela; superior distal margin projecting as acute tooth, inferointernal margin with strong tooth distally. Large chela of female similar in form but relatively much smaller.

Small chela sexually dimorphic. Male chela 0.8 as long as carapace, subcylindrical, tapering, 3 times as long as broad, without sculpturing. Dactylus balaeniceps, approaching half length of chela. Carpus slightly elongate, 0.25 length of chela. Merus 2 times as long as broad without inferointernal tooth. Small chela of female conical and tapering, fingers 0.7 length of palm, without balaeniceps dactylus.

Carpal articles of second legs with ratio: 10:10:3:4:5.

Third leg with strong spine on ischium. Merus 3.5 times as long as broad, with acute tooth subterminally on inferior margin. Carpus 0.5 as long as merus, inferior margin projecting as a strong tooth. Propodus about 0.8 as long as merus, tapering, with many spines. Dactylus variable, from simple to carrying small secondary unguis.

Telson almost twice as long as broad, sides almost parallel, posterior margin arcuate. Dorsal spines heavy, distolateral margins of inner uropod with several spines.

DISCUSSION: The rostrum in this species is extremely variable. In some specimens, particularly in the small ones, the taper of the sides of the rostrum is uniform to the tip. The tip of the rostrum varies from reaching just beyond the orbital margin to near the end of the first antennular article. The carpus of the second leg may have the second article somewhat longer than the first. The variation in the dactylus of the third leg has been remarked upon before (Banner 1959:141).

BIOLOGICAL NOTES: This species is found mainly intertidally under rocks or in heads of coral. However, it was dredged off Hawaii at a moderate depth (Banner, 1953:122). The colour in the Hawaiian specimens was ". . . variable, but it was usually dark, olive green, reddish brown, etc. with pronounced mottling of lighter colour; specimens at times almost transparent." (Banner, 1953:119).

AUSTRALIAN DISTRIBUTION: This species has been collected on the east coast from off Port Douglas, Qld., south to the Whitsunday Group. We also have some specimens

from the Coral Sea. Nobili himself *(loc. cit.)* thought the identity of his specimen from Beagle Bay in Western Australia was questionable.

GENERAL DISTRIBUTION: This species has been collected from the Red Sea, Indian Ocean, Japan and across the central Pacific to Hawaii.

Alpheus gracilipes Stimpson
Fig. 41

Alpheus gracilipes Stimpson, 1861:31. De Man, 1924:43, fig. 15. Banner and Banner, 1966b:112, fig. 39.

Crangon gracilipes Banner, 1953:115, fig. 41.

Nec Alpheus gracilipes Miers, 1884:287 (= *A. miersi* Coutière, 1898d.)

Nec Alpheus gracilipes Bate, 1888:561, pl. 101, fig. 3. Bass Strait Victoria. (Identity uncertain).

Previous Australian records:
Coutière, 1900:411. Thursday Is., Murray Is., Torres Straits.
McNeill, 1968:17. Low Is., Qld.

SPECIMENS EXAMINED: 1 specimen from AM74 (AM P. 27499); 2, AM 151 (AM P. 27826); 1, AM 186 (AM P. 27327); 4, AM 305 (AM P. 27778); 2, AM P. 7522; 1, AM P. 27431; 2, BAU 10; 1, BAU 46; 2, JG 22-73; 1, WM 221-65.

DIAGNOSIS: Rostrum narrow, triangular, acute, flattened dorsally, without carina, reaching almost to end of first antennular article. Rostral base separated from posterior portion of orbital hoods by deep narrow depressions, more anteriorly by wide flattened areas; abrupt sides of rostrum overhanging grooves. Orbital hoods inflated, large with abrupt medial margin, posteriorly merging with carapace, anteriorly with a rounded dorsoventral keel, which project beyond concave orbitorostral margin.

Antennular peduncle with second article 2 times as long as broad, 1.5 times longer than visible part of first article and over twice as long as third article. Stylocerite reaching to end of first antennular article. Scaphocerite with lateral margin slightly concave, squamous portion narrow, reaching to end of peduncle, lateral tooth reaching beyond end. Carpocerite reaching only slightly beyond second antennular article. Acute tooth of basicerite nearly as long as stylocerite.

Large chela slender, sub-cylindrical, 3.5 times as long as wide, with fingers occupying distal 0.4. Dactylus heavy, compressed, strongly arcuate, longer than fixed finger; plunger of minimal development. Palm with deep broad transverse groove proximal to articulation of dactylus. Merus 2 times as long as broad proximally, bearing an acute tooth distally on inferior margin and 2 small spines proximally; superior margin projecting into rounded tooth.

Small chela slender, 5 times as long as broad. Dactylus balaeniceps in both male and female with continuous setiferous crest passing over superior margin proximal to tip, but without usual lateral expansion of finger. Merus similar to that of large chela except tooth on superodistal margin is acute.

Carpal articles of second legs with ratio: 10:8:3:3:5.

Ischium of third leg with spine. Merus 6 times as long as broad, innermous. Carpus 0.5 as long as merus, superior margin terminating in a subacute tooth. Propodus nearly as

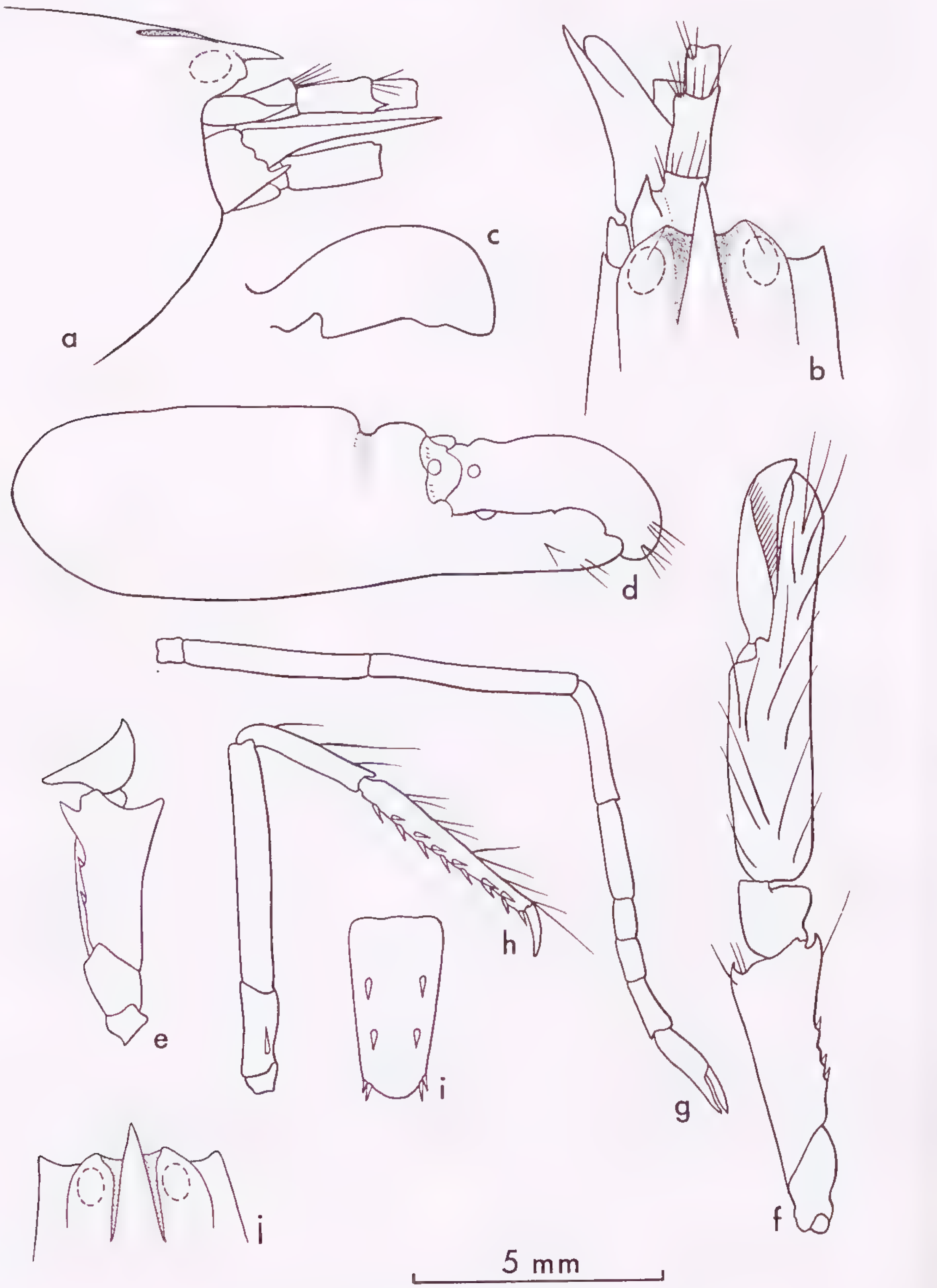

Fig. 41 *Alpheus gracilipes* Stimpson
35 mm female from AM P. 2577. **a, b.** Anterior region lateral and dorsal view; **c, d.** large chela and dactylus, lateral face; **e.** merus of large cheliped, medial face; **f.** small cheliped, medial face; **g.** second leg; **h.** third leg; **i.** telson. 24 mm male from AM 305. **j.** Anterior region, dorsal view. All figures same scale.

long as merus, bearing on inferior margin 10-16 spines and a pair distally. Dactylus slender, simple, 0.2 as long as propodus.

Telson 3.2 times as long as posterior margin is broad, posterior margin broadly arcuate, anterior pair of dorsal spines placed anterior to middle. Inner spines of posterior pair equal in length to dorsal spines.

DISCUSSION: The ratio of the length of the rostrum to its width at the base varies from 1.7-2.5 (compare figures 41b and 41j). Its length also varies from 0.7 length of visible part of the first article to the end of the that article. On the orbital hoods the anterior crest varies from rounded to almost acute giving the appearance from dorsal view of subacute teeth. The second antennular article is often more slender and may be over 2 times as long as the visible part of first. The first carpal article of the second leg varies from being equal in length to the second article to being somewhat longer.

The specimen that Bate reported as *A. gracilipes* from the Bass Straits is far beyond the tropical range we have found for this species in Australia. The frontal regions of the carapace are shown without orbitorostral grooves (fig. 3c) and are somewhat reminiscent of the fronts found in the genus *Synalpheus;* Bate himself remarks that the antennular peduncles are not of the proportions reported for *A. gracilipes;* the two views of the large chela (fig. 3, 3k) are difficult to interpret, but do not show the strong transverse groove behind the dactylar articulation; the slender and lightly armed distal end of the propodus and the very slender dactylus of the third leg (fig. 3m) again is unlike this species, and finally the telson is unlike any we have seen in this family. Inasmuch as the specimen cannot be found with the other *Challenger* material at the British Museum (Natural History), we will have to leave it without being able to assign it to a genus, let alone to any known species.

BIOLOGICAL NOTES: This species is apparently an intertidal form and has been collected under rocks and in heads of dead coral taken from water less than 6 m deep. We have no colour notes for the Australian specimens, but we do have colour notes from Hawaii and they compare favourably with the colour notes Coutière made from specimens from Djibouti (1898i:197). The chelipeds and thoracic legs were blue tinged with orange-red. The body was blue with oblong irregular patches of white which were sprinkled with orange-red pigment spots giving an overall rusty appearance. The most characteristic thing was a large round black spot tinged with orange on the pleura of the second to fourth abdominal segments. This colour pattern has appeared consistently on every specimen we have collected in Hawaii. Miya (1974:152) also reports these "eye spots" on the abdominal segments in specimens from Japan. This is a large species, the largest in our collection being 44 mm in length.

AUSTRALIAN DISTRIBUTION: In western Australia we have specimens from Yampi Sound and Cape Leveque; it has been collected in the north at the Torres Straits, and on the east coast from the Coral Sea to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: Red Sea; East Africa; Indonesia; Vietnam; Korea; Japan; New Caledonia* and across the central Pacific to Hawaii and Tahiti.

Alpheus novaezealandiae* Miers
Fig. 42

Alpheus novae-zealandiae Miers, 1876:224. Yaldwyn, 1956:806, figs. 1-7 (redescription of

*To be spelled without hyphen according to both 1961 and 1964 revisions of the International Codes of Zoological Nomenclature.

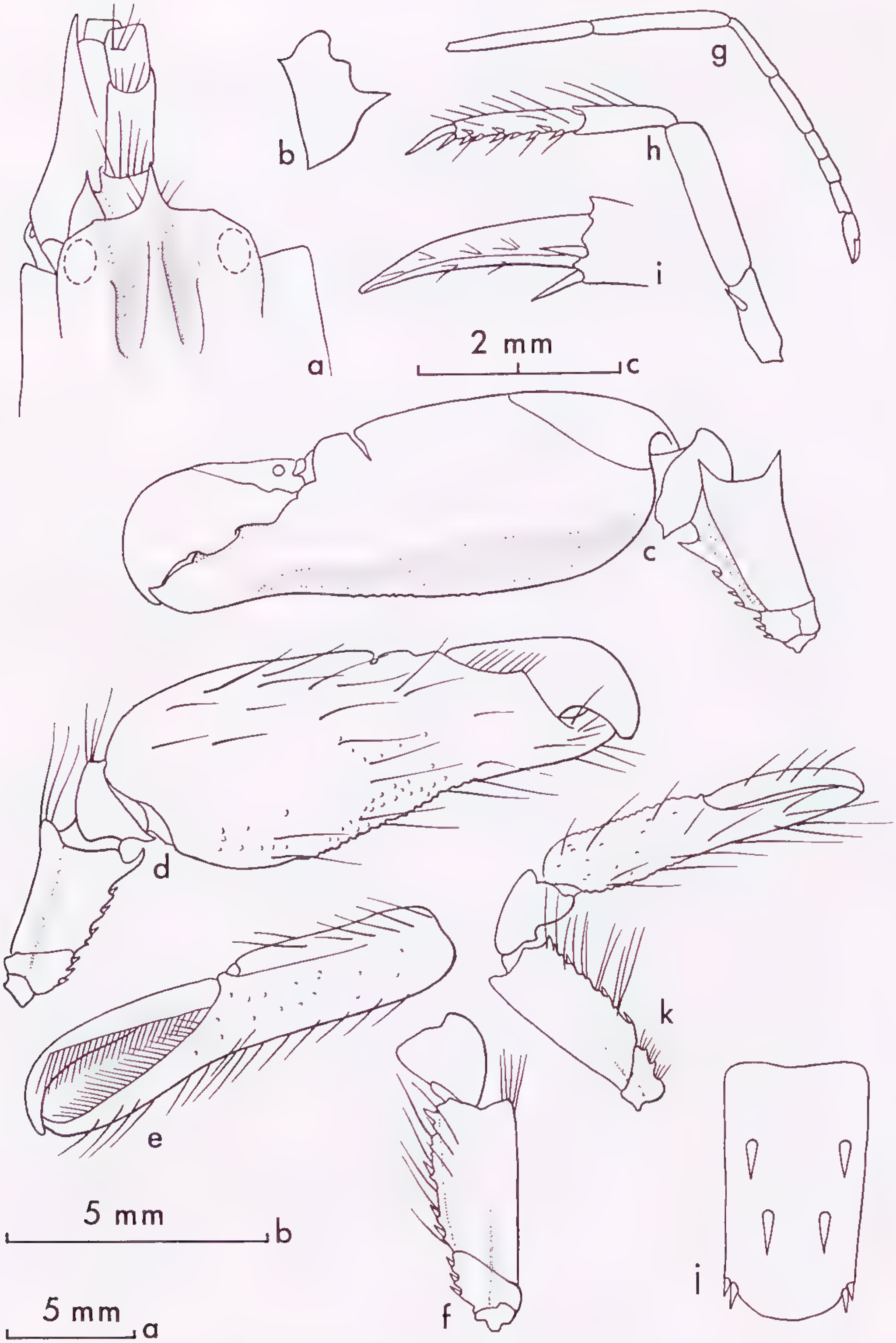

Fig. 42 *Alpheus novaezealandiae* Miers
45 mm male from AM P. 9423. **a.** Anterior region, dorsal view; **b.** basicerite; **c, d.** large cheliped, lateral and medial face; **e, f.** small chela and merus, medial face; **g.** second leg; **h, i.** third leg and enlarged dactylus; **j.** telson. 50 mm female from AM 320. **k,** Small cheliped, medial face, c, d, e, f, g, h, k scale a; a, b, j scale b; i scale c.

type material).

Crangon novae-zealandiae Hale, 1927a:47, fig. 39; 1927b:308.
Previous Australian records:
Hale, 1927a. South Australia
Hale, 1927b. Baeres Pt., Kangaroo Is.

Specimens examined: 1 specimen from AM13 (AM P. 27528); 2, AM 230 (AM P. 27854); 1, AM 296 (AM 27883); 2, AM 320 (AM P. 28149); 2, AM 323 (AM P. 27355); 6, AM 325 (AM P. 27356); 1, AM 452 (AM P. 27855); 2, AM G. 4249; 1, AM P. 1542; 1, AM P. 1543; 1, AM P. 3662; 1, AM P. 4480; 1, AM P. 4760; 8, AM P. 4838; 6, AM P. 6102; 1, AM P. 9337; 1, AM P. 9423; 2, AM P. 11732; 1, AM P. 13557; 1, AM P. 13575; 6, BAU 5; 2, BAU 42; 1, BAU 55; 1, CS 44; 1, CS 45; 1, MM 204; 161, QV 1971-10-2, 4-13; 6, SM C-511; 4, MM 161; 3, SM C-514; 1, SM C-518; 1, SM C-1066; 1, TM G1102; 1, TM 12879/G52; 1, TM 16630/G425; 1 specimen each from VM 3-9; 33, VM 10; 2, VM 12; 1, VM 13; 6, VM 14; 1, VM 26S; 4, VM 984; 1, WM 23-65a; 1, WM 29-65; 2, WM 84-65; 1, WM 126-65; 1, WM 127-65; 1, WM 147-65; 1, WM 178-65; 1, WM 188-65; 1, WM 202-65; 1, WM 211-65; 3, WM 227-65; 1, WM 237-65; 1, WM 258-65; 1, WM 9522; 1, WM 12112.

DIAGNOSIS: Rostrum narrow, awl-shaped, reaching just beyond end of first antennular article, free portion somewhat rounded dorsally; portion from front edge of carapace to between eyes with parallel sides and flattened dorsally, posterior portion of base triangular and without carinae or nobs; margins overhanging grooves from near orbitorostral margin to posterior end. Orbital hoods inflated, rounded, but carrying crest also overhanging groove from posterior termination to mid-eye region; anterior to mid-eye region crest continues as sharp and well-demarked, but not overhanging, curving laterally to form rounded vertical crest on anterior margin of orbital hoods; crest finally flowing into orbitorostral margin. Orbitorostral margin concave, orbitorostral grooves deep and with surface flattened. Visible part of first antennular article 0.5 as long as third article; second article 1.7 times longer than first and 1.7 times as long as broad. Distal margins and surface of antennular article beset with setae, distal margins of first and third article bearing short setiferous bristles. Stylocerite acute, reaching to end of first antennular article, also bearing setiferous bristles on lateral margins. Outer margin of scaphocerite concave, distal tooth directed inward at tip, reaching just past antennular article; squame moderately broad, reaching to near end of antennular peduncles. Carpocerite stout, 3 times as long as broad and as long as lateral tooth of scaphocerite. Basicerite with strong inferior tooth.

Large chela compressed, 2.8 times as long as broad, fingers occupying little more than distal third. Palm with narrow and deep transverse groove proximal to dactylus. Lateral face glabrous with longitudinal depression along lower margin arising near carpal articulation, disappearing near middle of pollex; superior margin of depression confluent with face; lower margin of depression separated from margin of palm by narrow to broad rounded crest. Superior margin of palm distal to transverse groove somewhat flattened. Internal face papillose and moderately setiferous. Dactylus compressed, rounded on superior margin, tip truncate and crossing pollex; plunger low. Carpus with rounded tooth projecting toward superomedial face of palm. Merus 1.5 as long as broad, not papillose, bearing on inferointernal margin 3 spines set on heavy protruding bases and bearing distally a strong curved and acute tooth. Ischium also bearing 3 spines on its inferointernal margin.

Small cheliped sexually dimorphic. Male chela 5 times as long as broad, fingers equal to palm. Palm papillose and setiferous on both faces, but less so on lateral face. Dactylus balaeniceps but not broadened, hairy crests not meeting on superior surface but nearly so. Tips of fingers crossing when closed, but cutting margins agape. Carpus cup-shaped, a little longer than that of large chela, bearing only one large rounded tooth on the distal

margin proximal to medial face. Merus 2.2 times as long as broad, similar to that of large chela. Small cheliped of female similar to that of male but not balaeniceps, and smaller in relation to the specimen than that of male.

Ratio of carpal articles of second legs; 10:10:3:3:5.

Ischium of third leg with spine. Merus inermous, 4 times as long as broad. Carpus 0.5 as long as merus with superior and inferior margins projecting distally as acute teeth. Propodus 0.7 as long as merus bearing on its inferior margin about 10 spines in an irregular row, and a pair of spines distally; superior margin bearing long fine setae. Dactylus 0.4 as long as propodus, trigonal, bearing tufts of short setae; inferior surface flattened but not excavate.

Telson about 2 times as long as broad at posterior margin, posterior margin nearly as broad as anterior margin and broadly arcuate. Posterolateral spines much smaller than dorsal spines.

DISCUSSION: The large chelae in the young specimens are not as papillose as the larger specimens, and the inferior margins are rounded, not knifelike. The small cheliped of the male is much larger in relation to the specimen than in the female. It is also noteworthy that on the anterolateral surface of the orbital hoods the exoskeleton is thin and transparent, providing a clear "window" through the hoods.

BIOLOGICAL NOTES: Their colour appears to be dark with white mottling, but variable. Hale (1927a:47) describes them as "...green, purplish or blue with white mottlings and spots; each branch of the uropods has a white marking on the upper side; the fingers of the large chela are tipped with orange, their outer margins are the same colour, and the inner margins are yellow." On the other hand, Yaldwyn noted with his collection (AM 325) a dark grey-green ground colour, with white mottling on body, but not on chelae, and with two purplish black spots on each side; he added that the legs were purple and the eggs brown.

In the intertidal zone this species has been collected under rocks; it has also been dredged as deep as 14 fathoms. In Jurien Bay the specimens were trawled at night above a stand of *Posidonia* grass. (BAU 5a) Dr. Gary Poore of the Fisheries and Wildlife Department in Melbourne reported that specimens of *A. novaezealandiae* collected at Port Phillip Bay (VM 984) came from cavities in the bases of clumps of the tunicate *Pyura stolonifera* but that the association "did not seem to be a commensal one" (personal communication).

Specimens in the collection ranged from 15-68 mm in length. (See *Alpheus* sp. following).

AUSTRALIAN DISTRIBUTION: Specimens have been collected on all coasts of Australia; in Western Australia from Albany to Exmouth Gulf; in the north from the Gulf of Carpentaria; in the east from Swains Reef to Sydney, and around the southern coast to St. Vincent's Gulf and Tasmania. One specimen came from Lord Howe Island.

GENERAL DISTRIBUTION: All records of this species have been from Australia and New Zealand.

Alpheus species
(= *Alpheus novaezealandiae* Miers, immature?)
Fig. 43

SPECIMEN DESCRIBED: a broken and incomplete female specimen, 10 mm long from Heron Island in the Capricorn group (BAU 54).

DIAGNOSIS: Rostrum slender, awl-shaped, reaching to last quarter of second

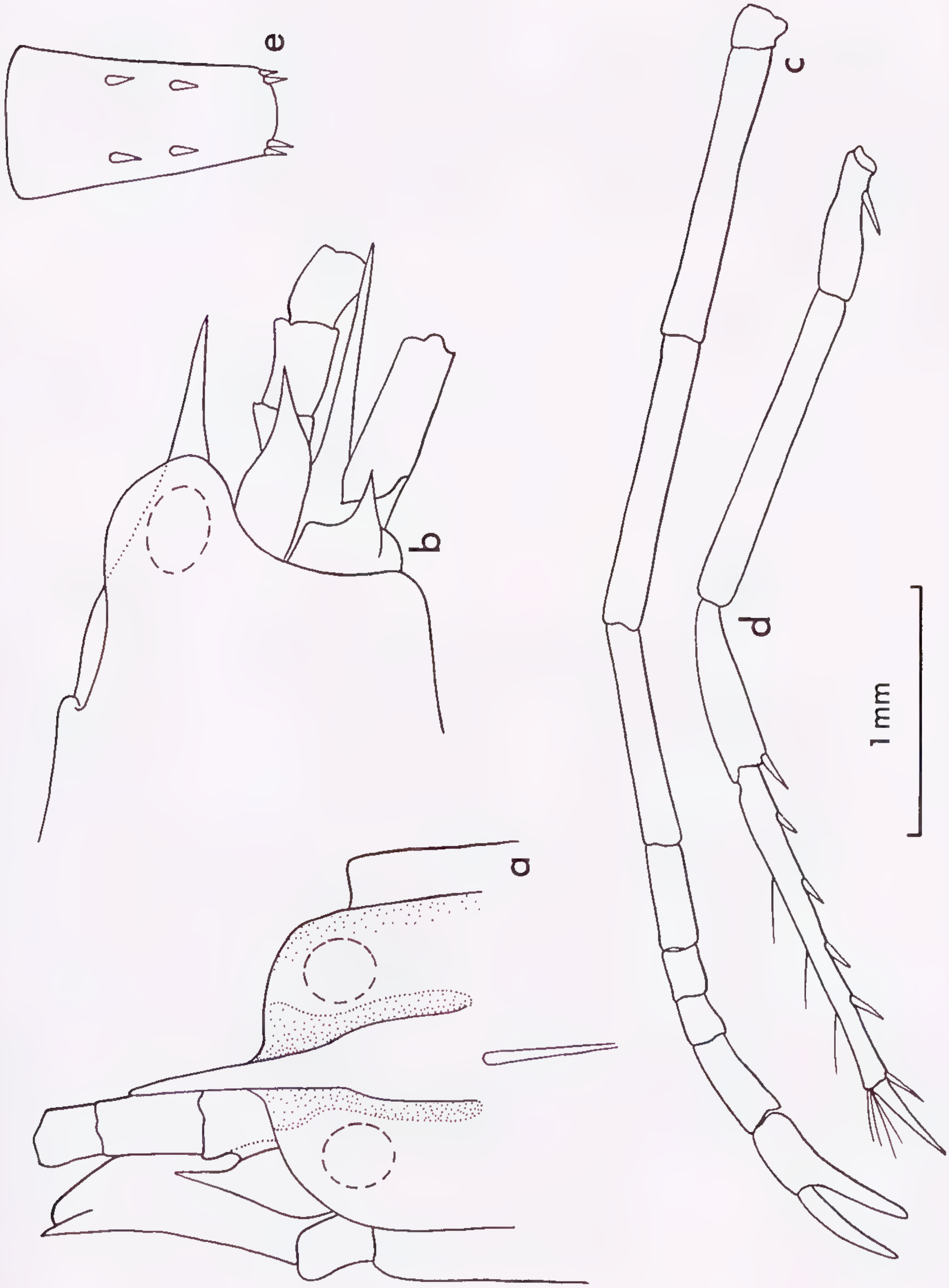

Fig. 43 *Alpheus* species
a, b. Anterior region dorsal and lateral view; **c.** second leg; **d.** third leg; **e.** telson. All figures same scale.

antennular article, free portion rounded dorsally, but flattening near margin of carapace; rostral base a narrow triangle expanding posterior to level of eyes, dorsally flattened with lateral margins overhanging orbitorostral grooves. At level of termination of rostral base lies a small rounded tubercle in midline that continues to mid-carapace as slight crest. Orbital hoods somewhat inflated, rounded with slight medial crest in position comparable to heavy overhanging crest of *A. novaezealandiae;* crest merging with anterior rounded vertical keel; keel of slight development. Orbitorostral margins not produced but flowing into margins of rostrum. Orbitorostral grooves deep, somewhat rounded. Visible part of first antennular article and third article subequal, second article a little longer, 1.7 times as long as broad. Stylocerite with prominent acute tooth that reaches to middle of second antennular article. Outer margin of scaphocerite concave, lateral tooth reaching to end of antennular peduncle, squamous portion a little shorter. Carpocerite reaching to middle of third antennular article.

Chelipeds missing.

Articles of the second legs with ratio: 10:5:2:2:4.

Ischium of third leg with spine, merus inermous, 8 times as long as broad. Carpus 0.5 as long as merus, superior margin projected as an obtuse tooth distally, inferior margin not projected distally but bearing a slender spine. Propodus slender, as long as merus, bearing on its inferior margin 4 spines and a pair distally. Dactylus simple, slender, 0.3 as long as propodus.

Telson 3 times as long as posterior margin is broad. Anterior pair of dorsal spines placed anterior to the middle.

DISCUSSION: We are cautious about this sole specimen because it is small, probably immature, and in poor condition. While obviously related in the form of the rostral base and orbital hoods to other species in the Diadema Group it differs from these other species by its long rostrum, the long stylocerites and the presence of a movable spine on the carpus of the third legs.

We are reminded of the small specimen we described as *Crangon (=Alpheus) latipes* (1953:82) which was later found to be a juvenile stage of *A. lottini* Guérin (Banner, 1958:164). In this small specimen the most distinctive characteristics of *A. lottini* were absent — the flattened rostral base, the hoof-life dactylus of the third legs, even the proportions of the appendages. We suggest, therefore, that perhaps this present specimen may be an early stage in the development of the common and much larger *A. novaezealandiae;* the smallest specimen in the collection we could identify as *A. novaezealandiae* was 15 mm long. This suggestion is based primarily upon the form of the rostral base and the presence of crests on the orbital hoods which in the same location are the strong crests of the mature *A. novaezealandiae*. However, in addition to the three differing characteristics listed above, the specimen also differs from *A. novaezealandiae* in the mid-dorsal tubercle and crest on the carapace, in the relative proportions of the first and second carpal articles of the second legs. It also has a more narrow and tapering telson and lacks the setae on the antennular peduncles. These differences may all be from immaturity, or this may be an immature stage of some yet undescribed species. This specimen was collected within the same depth range of *A. novaezealandiae*.

BREVIROSTRIS GROUP

Orbital teeth lacking; orbital hoods often prominent. Large chela always

compressed, more or less quadrangular in section often with faces demarked by noticeable angles; with or without transverse groove proximal to dactylus. Small chela of males at times balaeniceps. Third legs with merus usually unarmed, dactylus always simple, at times flattened and subspatulate.

The species in this group are found characteristically in burrows of their own construction in silty to silty-sandy bottoms, often in quiet estuarine conditions or in the mud of deeper bottoms where they are gathered in commercial shrimp trawls. They are seen using their chelae as bulldozer blades to shove the finer sediments from their burrows, but carry the small pebbles out individually. Some species live commensally in their burrows with gobiid fishes (see p. 182). In some species may be found some of the largest individuals reported in the family.

Chace (1974:67) has suggested that some of the variable Indo-Pacific species in the Brevirostris Group should be compared to some equally variable species known from the Atlantic, such as *A. floridanus* Kingsley, to determine if they might not be one or several species of circumtropical distribution. While there is much merit in Dr. Chace's suggestion we have not done so in this paper as we lack the Atlantic species for comparison (see discussion under *A. djiboutensis* De Man, p. 180).

Alpheus acutocarinatus De Man
Fig. 44

Alpheus acutocarinatus De Man, 1909a:104; 1911:401, fig. 94. Banner and Banner, 1966b:120, fig. 43.

SPECIMENS EXAMINED: 1 specimen from UQ 13; 2, UQ 18.

DIAGNOSIS: Rostrum acute, longer than broad at base; tip reaching just past middle of visible part of first antennular article; rostral carina sharp and interrupted well posterior to orbital hoods by a tooth and continuing to posterior third of carapace. Orbital hoods strongly inflated forming deep orbitorostral grooves. Second antennular article 4.5 times as long as wide, almost twice as long as visible part of first article and 3 times as long as third article. Stylocerite acute, not reaching end of first antennular article. Scaphocerite narrow, lateral tooth reaching to near middle of third antennular article, squamous portion almost equal to lateral tooth; outer margin slightly concave. Carpocerite reaching to end of second antennular article.

Ratio of articles of third maxilliped: 10:3:5. Inner distal margin of second article bearing tuft of long hairs that slightly surpasses third article.

Large chela oval in section, only moderately compressed, 6.0 times as long as broad, fingers occupying distal 0.3, plunger of dactylus minimal. Superior and inferior margins bearing long, fine, forward-sweeping hairs. Surface of chela lightly granular. Carpus cup-shaped, 0.2 as long as chela. Merus slender, almost 5.0 times as long as wide, inferointernal margin bearing acute tooth distally and one strong spine slightly proximal to middle; surface of merus more granular than chela, margins rough and irregular.

Small chela nearly as long as large chela but more slender. According to De Man (1911:403) small chela sexually dimorphic with elongate dactylus in males only slightly shorter than palm and balaeniceps; in the females in this collection the dactylus was normal and subequal in length to palm; chela in both males and females 9 times as long as broad, with palm oval in section and bearing long, forward-sweeping hairs on margins; surface less granular than that of large chela. Merus similar to large cheliped.

Carpal articles of second legs with the ratio: 10:10:5:5:4.

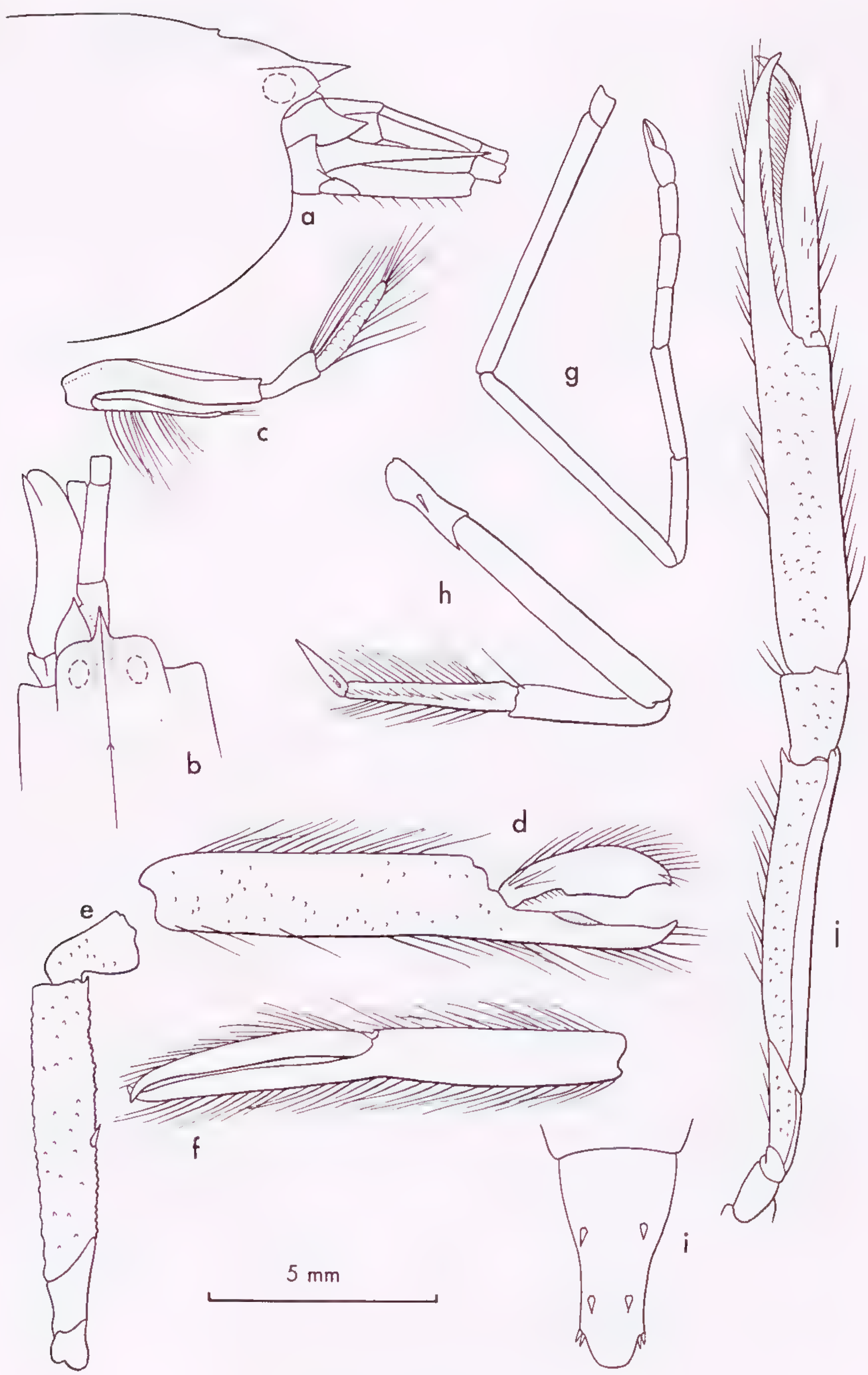

Fig. 44 *Alpheus acutocarinatus* De Man
35 mm female from UQ 18. **a, b.** Anterior region, lateral and dorsal view; **c.** third maxilliped; **d, e.** large chela and merus, medial face; **f.** small chela, medial face; **g.** second leg; **h.** third leg; **i.** telson. After De Man, 1911, fig. 94D. **j.** Cheliped of male. All drawings same scale except j.

Ischium of third legs bearing small spine. Merus inermous, 8 times as long as broad. Carpus 0.5 as long as merus, superior margin projected as an obtuse tooth. Propodus 0.6 as long as merus, inferior margins without spines, but both superior and inferior margins bearing long fine setae; two other rows of short setae on flattened faces, parallel to margins. Dactylus 0.4 as long as propodus, spatulate, slightly excavate on its inferior surface.

Telson elongate, 3.3 times as long as posterior margin is wide, 1.9 times as wide anteriorly as posteriorly; lateral margins concave; strongly arcuate tip extending by 0.15 of total telsal length beyond small posterolateral spines.

DISCUSSION: We have compared our specimens to De Man's holotype in the Zoologisch Museum in Amsterdam and find only one slight difference. The third leg on our 3 specimens had a merus that was 9 rather than 8 times as long as broad. De Man noted, but failed to show, the ischial spine on the third leg; it is present in the holotype as well as the Australian specimens. The extent of variation in this species cannot be projected from the 8 specimens ever reported.

BIOLOGICAL NOTES: The specimens from Moreton Bay were from 10 fathoms and De Man's 5 specimens were dredged from 26-72 m. He reported them from muddy bottoms and presumably the habitat in Moreton Bay was similar. The Thai specimens were also dredged and probably from sandy-to-muddy bottoms.

AUSTRALIAN DISTRIBUTION: The only record is from Moreton Bay, Queensland.

GENERAL DISTRIBUTION: Indonesia and Gulf of Thailand.

Alpheus stephensoni Banner and Smalley
Figs. 45, 46

Alpheus stephensoni Banner and Smalley, 1969:43, fig. 2.

Previous Australian records:
Banner and Smalley, *(loc cit.)*. Moreton Bay, Qld.

SPECIMENS EXAMINED: 1 specimen from AM P. 12927; 1, AM P. 12936; 1, QM W 2238; 1, UQ 27; 21, UQ 30; 32, UQ 31; 39, UQ 32; 3, UQ 34; 1, VM 23.

DIAGNOSIS: "Rostrum acute, awl-shaped, reaching past end of first antennular article. Rostral carina pronounced, knife-edged, disappearing abruptly at 0.4 length of carapace. Orbital hoods inflated, forming moderately deep grooves between hoods and high rostral carina. Orbitorostral area set off distinctly from lateral regions of carapace, more narrow in relation to carapace than usual for *Alpheus*. Carapace covered with small bosses. Second article of antennular peduncle 3 times as long as broad. visible part of first antennular article and third article sub-equal, first article about one-third as long as second. Lateral margins of antennular peduncles beset with dense, fine hair. Antennular flagella somewhat shorter than body length; antennal flagella somewhat longer than body. Lateral margin of scaphocerite straight, lateral spine only slightly longer than squamous portion. Squamous portion narrow distally. Carpocerite reaching to end of second antennular article, antennae long, often as long as entire shrimp. Stylocerite acute, reaching to end of first antennular article, lateral margin fringed with fine hairs. Basicerite with strong lateral spine. Tip of third maxilliped reaching beyond end of antennular peduncles when extended.

"Large chela compressed, 3.7 times as long as broad. Palm covered with small bosses, less abundant near distal end; superior margin rounded, bearing towards the

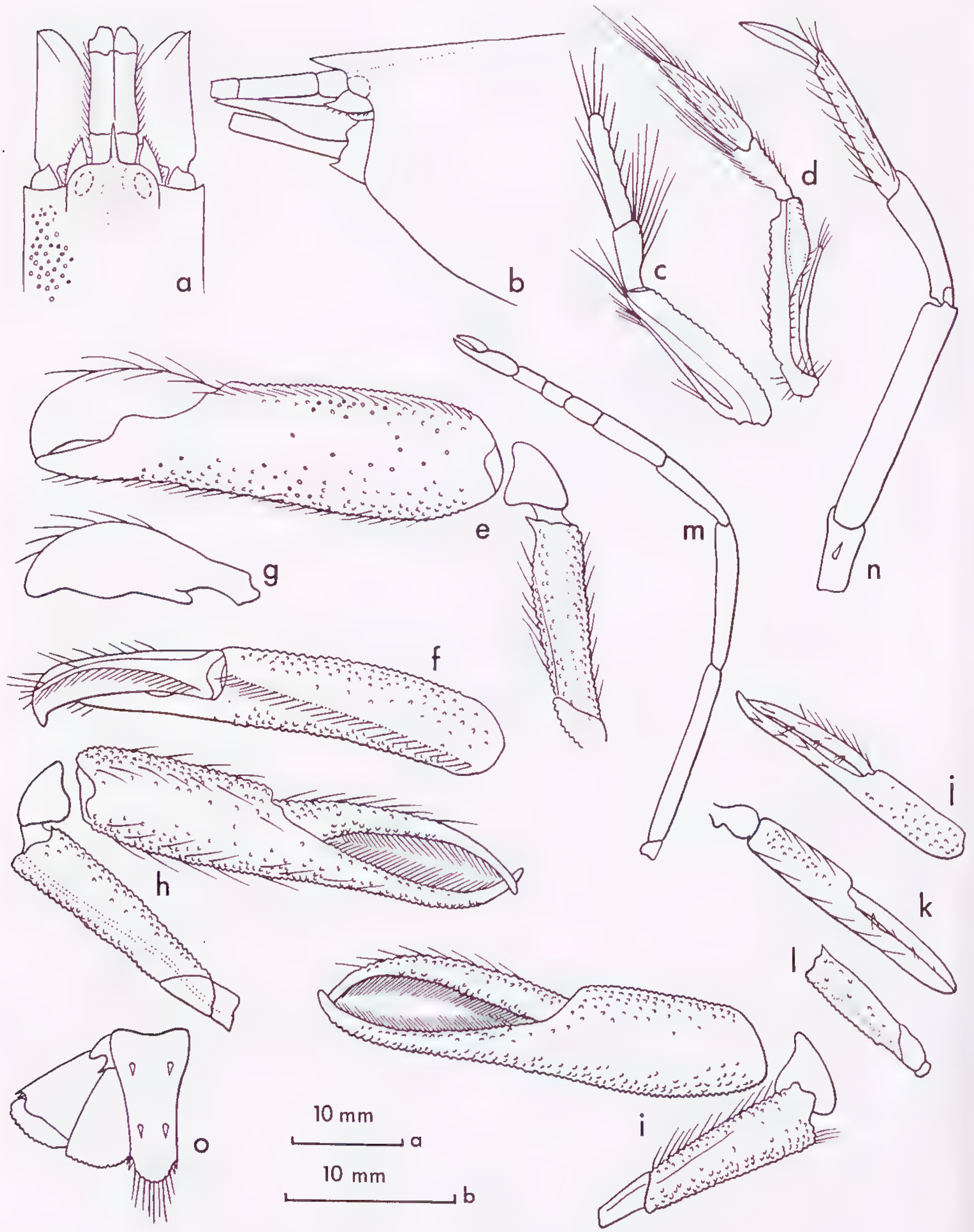

Fig. 45 *Alpheus stephensoni* Banner and Smalley
a, b. Anterior region, dorsal and lateral view; **c, d.** third maxilliped, lateral and medial face; **e.** large cheliped, medial face; **f.** large chela, superior face; **g.** dactylus of large chela, medial face; **h, i.** small cheliped, male, medial and lateral face; **j, k.** small chela, female, medial and lateral face; **l.** merus small chela, female, medial face; **m.** second leg; **n.** third leg; **o.** telson and uropods. a, b, e, f, g, h, i, j, k, l scale a; c, d, m, n, o scale b. (Figures from 70 mm male holotype and 64 mm female. After Banner and Smalley, 1969, fig. 2 with the exception of figure g).

Fig. 46 *Alpheus stephensoni*, regenerating chelae
75 mm male from AM 347. **a.** Large cheliped, medial face; **b.** view of oppositive face of pollex showing developing socket; **c.** small cheliped (fingers broken). a, c scale a; b scale b.

inner face a row of forward-sweeping hairs; inferior margin flattened and bearing rows of hairs similar to superior margin; inner face flat; outer face a little rounded toward the superior margin but longitudinally slightly grooved near the inferior margin; groove not extending into finger. Dactylus 0.38 as long as entire chela, superior margin slightly flattened bearing a row of fine setae on inner margin of flattened portion. Fingers slightly crossing; surfaces with a few long setae, but no bosses. Merus 3.7 times as long as broad, surface covered with small bosses. Distal end of superior margin not armed, inferior internal margin bearing row of fine hairs, distal end with strong acute tooth. Inner face bearing a shallow longitudinal groove near superior margin. Large chela of female slightly smaller than male chela.

"Small chela of male highly compressed, 4.8 times as long as broad, entire surface covered with small bosses. Fingers only slightly longer than palm. Inner face of chela beset with forward-sweeping hairs, superior and inferior margins rounded. Superior margin of dactylus with sharp crest. Fingers bearing dense fringe of setae along lateral margins of opposing faces. Fingers gaping, tips crossing. Merus 3.6 times as long as broad, surface covered with small bosses. Inferointernal margin bearing fine hairs, distal end armed with pronounced tooth. Inner face bearing a narrow longitudinal groove near superior margin, similar to groove on merus of large chela.

"Small chela of female highly compressed, about one-third as large as that of male, 6.5 times as long as broad, fingers a little longer than palm. Dactylus slightly shorter than fixed fingers. Fingers with patches of short stiff setae near opposing surfaces, but no fringe of setae as found in male. Palmar surface with bosses similar to large chelae. Inner face partially covered with forward-sweeping setae set into superior and inferior margins. Merus similar to that for large chela with tooth on inferodistal margin and a slight narrow groove longitudinally near the superior margin.

"Carpal articles of second leg with ratio: 10:8:3:3:3.

"Ischium of third leg with small spine. Merus 6 times as long as broad, unarmed. Carpus almost half as long as merus. Propodus 0.6 as long as merus, without movable spinules but with 3 longitudinal rows of stiff setae. Dactylus spatulate, 0.3 as long as merus.

"Telson 3.2 times as long as posterior margin is broad. Posterior margin strongly arcuate with rounded tip extending well beyond lateral spines." (Original description).

DISCUSSION: The variation in this species is discussed in the 1969 paper.

The chelae on the 75 mm male specimen from AM 347 are anamolous (fig. 46). The large chela is 2.8 times as long as broad, with the fingers slightly longer than the palm; the socket of pollex is well demarked and relatively deep, but the plunger of the dactylus is only slightly developed and cannot reach the bottom of the socket. The distal portions of the fingers carry knife-like edges, meeting only in the middle third and gaping in the distal third; tips curved and crossing. The large chela is covered with rounded bosses and hairs. The small chela is simple with distal portion of fingers broken off; the fingers, where broken, are oval in section with oppositive faces slightly angular and bearing rows of short stiff setae that cross. The palm is relatively smooth and bears only slightly developed rows of setae. Otherwise the specimen falls well within the range of variation of *A. stephensoni*. We were originally going to give the specimen a separate description as a questionable *A. stephensoni,* but Dr. John C. Yaldwyn has suggested to us that it was likely that the specimen had lost its large chela and was in a series of moults in which the small chela was changing to the form of the large chela and the regenerating chela was being transformed into a normal small chela. This phenomenon is well known, but

seldom have we seen chelae of such intermediate development.

BIOLOGICAL NOTES: This species has been largely caught in shrimp trawls in water up to 10 fms. It has been caught especially at night and seems to be more abundant in the summer months. Specimens caught in early spring often are heavily encrusted with hydroids and tube worm cases. All alpheids caught on muddy grounds east of Redcliffe, Qld. are likely to be this species.

"The carapace is blue-green dorsally; rostral carina is brown. Abdomen olive dorsally, and often red laterally; along lower edges of pleura is a white band continuous with the white branchiostegites. Tergum markings usually include brown transverse band along posterior edge of each tergum, various small colourless patches assuming bilateral symmetry, and a medial colourless line on anterior of first tergum and on sixth tergum continuing posteriorly on telson. Telson also with two white patches proximally and a white spot around base of each of the four spines.

"Antennules and antennae mostly brown, but blue-green at bases. Inner faces of large and small chelipeds with proximal ends of fingers, palm, and carpus, and distal end of merus all olive mottled on pale pink background, but for blue inferior internal edge of palm; most of fingers blue over pale pink with extreme tips white. Outer faces of chelae purplish or pink. Uropod reddish with blue and brown borders. Other appendages red distally, white proximally." (Colour notes by Smalley, *loc. cit.*).

AUSTRALIAN DISTRIBUTION: This species has been reported in eastern Australia from Bundaberg, Qld. to Port Jackson, N.S.W.

GENERAL DISTRIBUTION: This species has never been reported out of Australia.

Alpheus distinguendus De Man
Fig. 47

Alpheus distinguendus De Man, 1909b:155, pl. 7, figs. 9-14. Banner and Smalley, 1969:47, fig. 3.
Alpheus rapax De Haan, 1850:177, pl. 45, fig. 2.? Bate, 1888:552, pl. 99, fig. 1. De Man, 1888b:264; 1892:404. Ortmann, 1890:481. Nobili, 1903:7. (*Nec* Fabricius, 1798.)
? *Alpheus brevirostris* De Man, 1907:427, pl. 33, figs. 51, 52.
? *Alpheus digitalis* De Haan, 1850:178, pl. 45, fig. 4. Coutière, 1898h:249, fig. 2 (= *A. rapax* De Haan).

Previous Australian record:

Banner and Smalley, *loc. cit.* Moreton Bay, Qld.

SPECIMENS EXAMINED: 1 specimen from AM 99 (AM P. 27771); 1, AM 125; (AM P. 27530); 1, AM 148; (AM P 27869); 1, AM 354; (AM P. 27536); 1, AM P. 14630; 1 each from CS 50, 51;1, MM 355; 1, QM W 2381; 1, UQ 17; 1, UQ19, 1, UQ 20; 32, UQ 28; 20, UQ 29; 1, UQ 33; 1, WM 134-65; 1, WM 162-65; 1, WM 199-65; 2, WM 237-65; 1, WM 241-65; 1, WM 242-65; 5, WM 284-65; 1, WM 131-76.

DIAGNOSIS: Rostrum awl-shaped, reaching to near end of first antennular article. Dorsal carina high and narrow, extending into carapace beyond orbits. Eye hoods inflated, forming broad deep grooves between eye hoods and dorsal carina. Visible part of first antennular article equal to third. Second article 3 times as long as third article and 3 times as long as wide. Stylocerite reaching to end of first antennular article, acute tip not

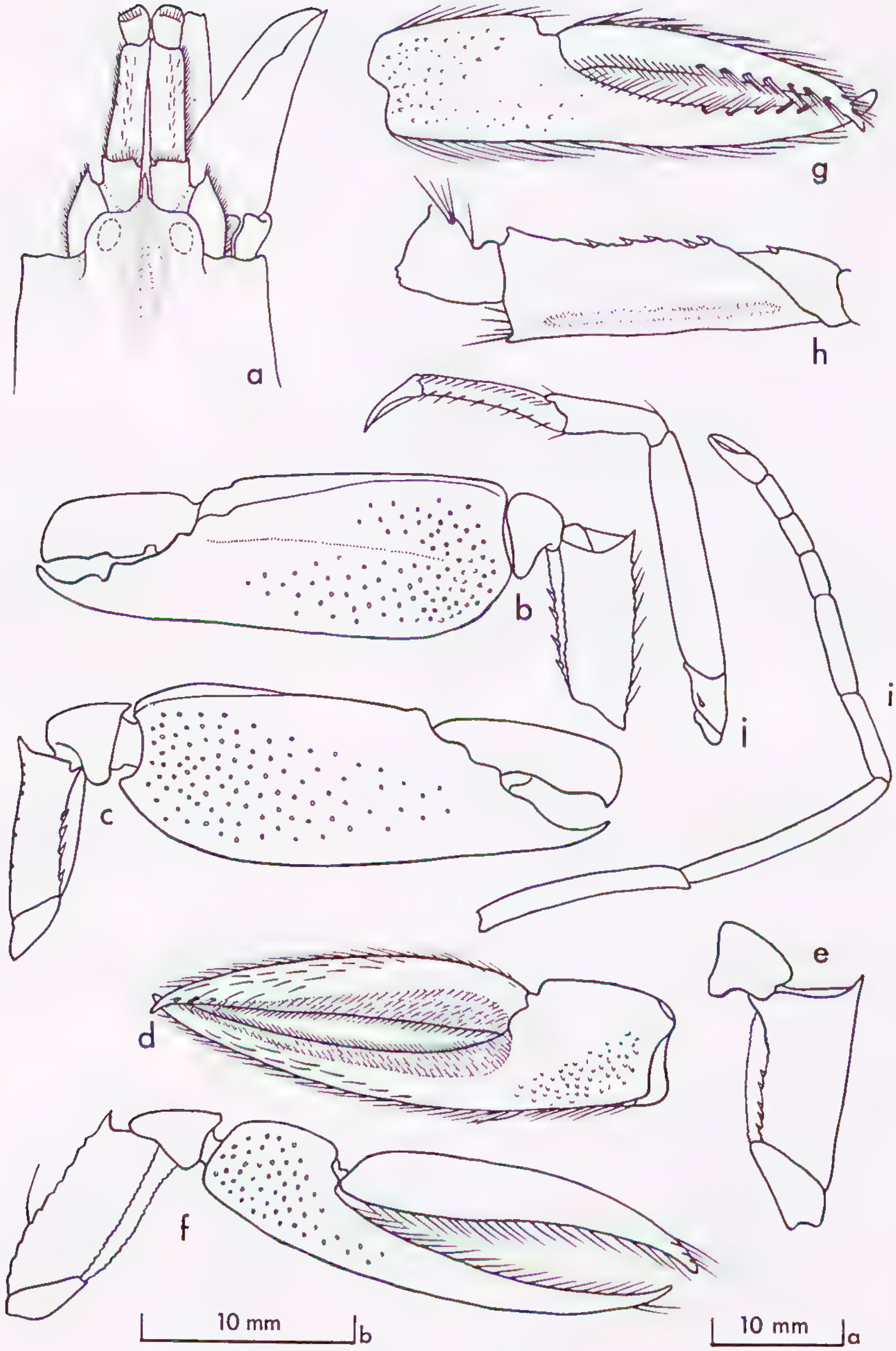

Fig. 47 *Alpheus distinguendus* De Man

a. Anterior region, dorsal view; **b, c.** large cheliped, lateral and medial face; **d, e.** small chela and merus, medial face; **f.** small cheliped, lateral face; **g, h.** small chela and merus, female, medial face; **i.** second leg; **j.** third leg. a, b, c, d, e, f, h, i, j scale a; g, h scale b. (Figures of 74 mm male and 70 mm female. After Banner and Smalley, 1969, fig. 3.)

directed medially, lateral margin of stylocerite and antennules beset with row of dense, fine setae. Scaphocerite with outer margin slightly concave, reaching well beyond antennular peduncle with tip of lateral tooth slightly longer than squamous portion. Carpocerite as long as antennular peduncle. Basicerite bearing small acute tooth.

Large chela compressed, 3 times as long as wide, with fingers occupying distal 0.3. Superior margin without transverse groove, but bearing along its entire length a flattened angled slant toward the outer face at the distal end of palm. Inner edge of flattened area bearing fine hairs directed forward. Lateral face bearing a diffuse longitudinal ridge about the middle of the face. Medial face flat. Inferior margin of chela knife-like, and bearing fine hairs directed forward along its entire length. Entire chela bearing fine bosses. Merus 2.7 times as long as broad. Superior margin terminating in an acute tooth. Inferointernal margin lightly serrate and bearing 4 movable spinules, terminating distally in an acute tooth. Inferoexternal margin without spinules, but bearing fine serrations along margin.

Small chela of male slender, 4.5 times as long as wide, palm covered with minute bosses. Fingers 2.8 times as long as palm, fingers crossing at tips. Dactylus longer than fixed finger. Opposing margins of fingers bearing brush of forward directed hairs. Outer faces of fingers show gape only near distal end when closed, but inner face shows wide arched gape along its entire length giving an excavate appearance. Opposing faces of fingers heavily hirsute. Merus similar to that of large chela.

Small chela of female about half the size of male small chela. Fingers 1.7 times as long as palm, fingers slightly gaping, crossing at tips. Opposing margins bearing slight row of criss-cross hairs. Patches of setae on lateral margins of fingers. Superior and inferior margin carrying long fine, forward-sweeping hairs. Merus similar to that for male but slightly more slender.

Ratio of carpal articles of second leg: 10:10:5:4:4.

Ischium of third legs with spine. Merus 7 times as long as wide, without spines. Carpus half as long as merus; propodus a little longer than carpus, bearing 2 rows of short hairs on its lateral face and inferior margin. Dactylus 0.5 as long as propodus, spatulate.

Telson 2.5 times as long as posterior margin is broad, proximal margin 1.5 times wider than distal. Distal margin broadly rounded. (Description modified from Banner and Smalley, *loc. cit.*).

DISCUSSION: When we redescribed *A. distinguendus* from specimens from Australia in 1969 we suggested that the overhang of the pollex of the dactylus of the small chela of the male might separate the Australian form from the Japanese form, the type locality. (The differences in finger length appearing in fig. 47d,f are the result of differing angles of view.) Since that time Dr. Yasuhiko Miya of the Institute of Biology, Nagasaki University, Japan has informed us that the specimens in Japan also have the overhanging dactylus (personal communication). The variation in the length-breadth ratio of the chelae that Miya found was also similar to that found in the Australian specimens.

After over 20 years of study during which time he was trying to separate various authors' use of the names *A. brevirostris* (Olivier) and *A. rapax* Fabricius, De Man came to the conclusion that almost all of the specimens he had placed under *A. brevirostris* were in actuality a different species to which he gave the name *A. distinguendus*. As we indicate under *A. brevirostris*, we have sincere doubts about the validity of this separation, but are continuing to use part of De Man's separation between the two nominal species.

Coutière after studying the specimens of De Haan from Japan, reported (1898h) that

A. digitalis De Haan, whose distinguishing characteristic was a strange large chela that Coutière decided was an anomalous form due to regeneration, was the form that De Haan had named *A. rapax* Fabricius (1850:177), but that De Haan's *A. rapax* was actually *A. brevirostris* (Olivier). Later, De Man (1909b:155) in his reconsideration of the Brevirostris Group, stated that De Haan's *A. rapax* and part of the specimens Coutière considered to be *A. brevirostris* belonged to his, De Man's, new species, *A. distinguendus*. Presumably, therefore, *A. digitalis* is a synonym of *A. distinguendus,* but this synonymy was never listed by De Man.

BIOLOGICAL NOTES: The specimens discussed in 1969 *(loc. cit.)* from Moreton Bay as well as most of the abovementioned specimens were caught in prawn trawls in less than 20 fathoms. Miya reports that specimens from Japan are caught on summer nights in prawn trawls, further he stated that in "... Hakata Bay, Fukuoka City, they are caught with the mantis shrimps *Oratosquilla oratoria* (De Haan)..." (Personal communication). The collecting notes indicated in the Australian specimens that they are commonly found in brackish water at the mouth of rivers. This species appears to live on the bottom or slightly above it. One 54 mm specimen from the Gulf of Carpentaria (AM 345) had an abnormal growth on the carapace giving it a "furry" appearance. The growth was tentatively identified by Dr. Michael Hadfield of the University of Hawaii as the bryozoan, *Triticella sp.* This genus is known to be attached to the exoskeletonof crustaceans (see: Hyman, 1959:431), but we previously have not seen any alpheids with this epizoic. In life the shrimp is green to brown dorsally, colourless to pale blue laterally, with longitudinal streaks on abdomen; tips of chelae orange to pink; legs lighter in colour (for full colour notes see Banner and Smalley, *loc. cit.*). Our specimens range up to 80 mm in length.

AUSTRALIAN DISTRIBUTION: This species has been collected in Western Australia from near Perth to Shark Bay and Kuri Bay in northwestern Australia; in northern Australia in the Gulf of Carpentaria and in eastern Australia from Cooktown, Qld. to Botany Bay, N.S.W.

GENERAL DISTRIBUTION: Mergui Archipelago; Singapore; China; Japan. (De Man was of the opinion that many of the earlier records of *A. rapax* Fabricius were actually *A. distinguendus*. As there can be no way to retroactively sort them, we have ignored them here. The range, therefore, may be much broader).

Alpheus rapacida De Man
Fig. 48

Alpheus rapacida De Man 1908:105; 1911:394, fig. 91. Barnard, 1950:750, figs. 142 a-f. Tiwari, 1963:302, fig. 21, 22. Lewinsohn and Holthuis, 1964:47, fig. 1. Banner and Banner, 1966b:118, fig. 42.

Alpheus rapax Bate, 1888:552, pl. 99, fig. 1. (*Nec* Fabricius , 1798.)

SPECIMENS EXAMINED: 2 specimens from AM 149; (AM P. 27553); 2, AM 288; (AM P. 27880); 1, JR 9; 2, UQ 1; 1 UQ 15; 1, UQ 16; 1, UQ 26; 2, WM 244-65.

DIAGNOSIS: Rostrum acute, reaching almost to end of first antennular article, with carina that extends almost to middle of carapace; anteriorly knife-like, posteriorly carina broader and rounded. Orbitorostral grooves deep with flattened bottoms. Visible part of first antennular article and third article subequal, second article 3 times as long as third and 3.5 times as long as broad. Outer margins of first and second article and stylocerite beset with setiferous bristles. Stylocerite acute, reaching to end of first antennular article. Outer margin of scaphocerite slightly concave; squamous portion narrow, reaching length of third article past antennular peduncle, lateral tooth a little longer. Carpocerite

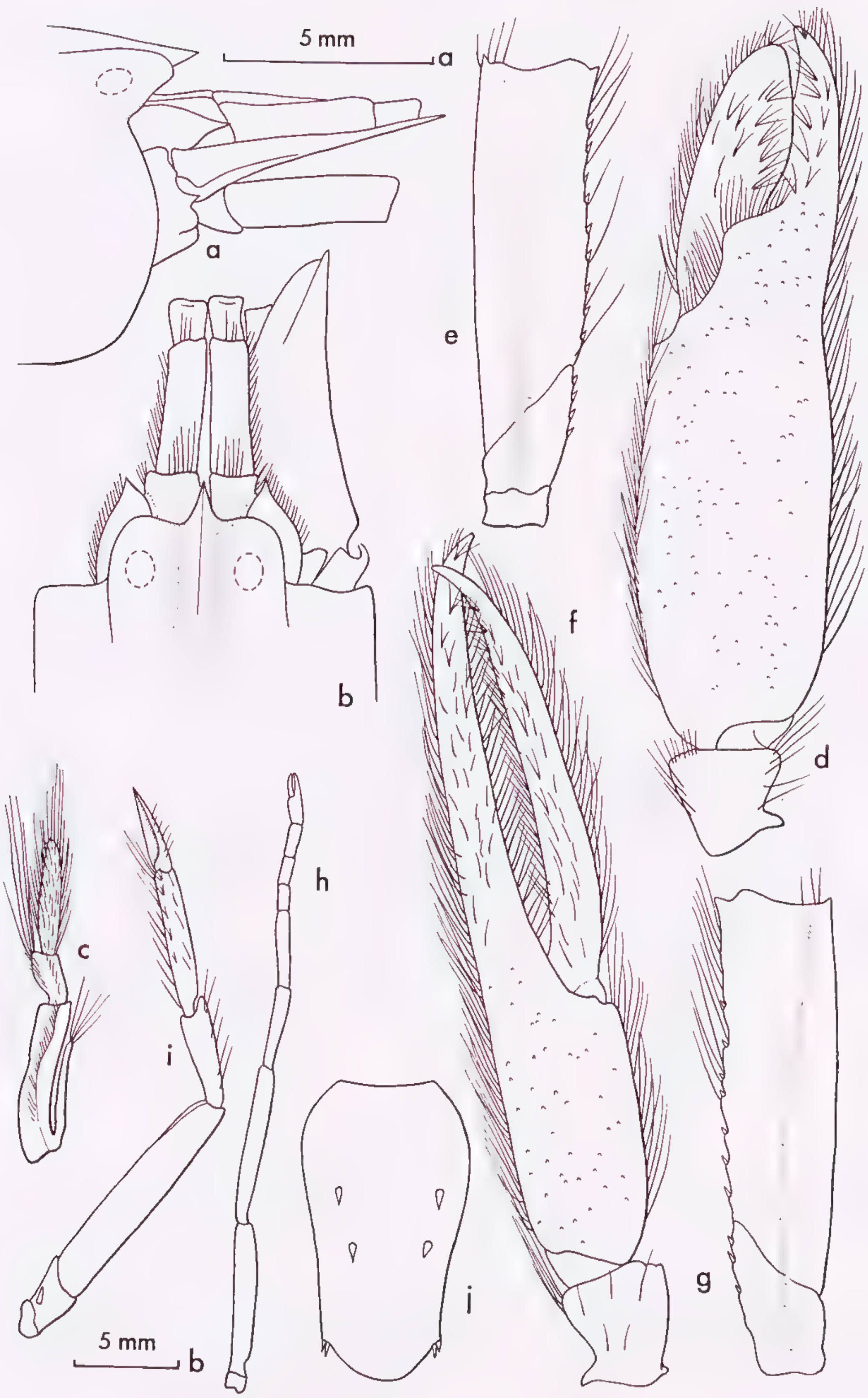

Fig. 48 *Alpheus rapacida* De Man
57 mm female from AM 288. **a, b**. Anterior region, lateral and dorsal view; **c.** third maxilliped, medial face; **d, e.** large chela and merus, medial face; **f, g.** small chela and merus, medial face; **h.** second leg; **i.** third leg; **j.** telson. a, b, c, d, e, f, g, j scale a; h, i scale b.

reaching to middle of third antennular article. Basicerite with small acute tooth on inferior margin.

Ratio of articles of third maxilliped: 10:3:7. Inferodistal margin of second article bearing patch of long setae most of which surpass tip of distal article. Tip of distal article bearing long setae. Third maxilliped exceeds length of antennules by half length of distal article.

Large chela compressed, 4 times as long as broad with fingers occupying distal 0.4. Upper margin of palm with flattened area, not cut by a transverse groove; medial margin of area carrying a row of long, forward-sweeping bristles; outer margin with row of sparsely set shorter hairs. Inferior margin thin but rounded bearing a row of setae directed anterolaterally. Entire surface of palm and proximal section of propodal finger granular. Dactylus smooth, superior margin carinate, tip truncate and slightly shorter than pollex. Plunger of dactylus of minimal development. Carpus short, slightly granular and sparsely hirsute. Merus 3.4 times as long as broad, surface slightly granular. Superior margin bearing obtuse tooth distally; inferointernal margin dentate, bearing a number of small spines and an acute tooth distally. Inferior margin of ischium also bearing a few small spines. Medial surface of both merus and ischium with narrow, deep, longitudinal groove located slightly superior to middle.

Small chelae of males and females similar, about as long as large chela, without ridges or grooves, 5.3 times as long as broad, fingers 1.8 times longer than palm. Inferior and superior margin bearing long forward sweeping hairs similar to large chela; surface of fingers bearing sparsely set, short, stiff setae. Opposing edges of fingers beset with short forward-sweeping hairs that cross in middle. Tips of fingers cross when closed, leaving a gape proximally. Merus similar to that of large chela.

Ratio of articles of second leg: 10:10:3:3:3.

Ischium of third leg with spine. Merus inermous, 5 times as long as broad. Carpus 0.4 as long as merus, superior margin projected slightly as a rounded tooth. Propodus 0.6 as long as merus, without spines on inferior margin, but with row of long setae; a second row of setae on lateral face with short and stiff bristles set in groups of 2 or 3; superior margin bearing similar bristles, but set singly. Dactylus spatulate and more than 0.4 length of propodus.

Telson 2.5 times as long as posterior margin is broad. Posterior margin arcuate, projecting far behind posterolateral spines. Anterior pair of dorsal spines set well anterior to middle.

DISCUSSION: The Australian specimens differ from De Man's in the following characters:

1. The rostrum reaches to near the end of the first antennular article instead of the middle.
2. The second antennular article is much longer in relation to the first and third with a ratio of 10:30:10 instead of De Man's ratio of 10:12:6.
3. The third maxillipeds reach beyond the antennules in our specimens instead of equal as in De Man's.

In addition, specimens in our collections from Hawaii and Madagascar have a slight transverse groove behind the dactylus of the large chela, a condition not noted in the Australian specimens. This seemed also to be indicated in Tiwari's figure of a specimen from Vietnam.

The first three differences were remarked upon by Lewinsohn and Holthuis (*loc. cit.*) with specimens from Israel and by Tiwari with his specimens from Vietnam; we find the same from Hawaii. We do not attach importance to any of these differences. We should remark that the condition of the large chela shown in figure 48d in which the dactylus is shorter than the pollex is not common.

We have examined the specimen from Hong Kong collected by the Challenger Expedition at the British Museum (Natural History) and identified by Bate as *A. rapax*, who probably based his identification upon De Haan's figure of what he, De Haan, thought was that species. Later, when De Man separated *A. rapax* Fabricius from the form De Haan had described, giving De Haan's form the name *A. distinguendus*, he did not know what to do with Bate's reference so merely listed it "?*Alpheus rapax* Spence-Bate" in the synonymy of *A. distinguendus*. The only difference between Bate's specimen and *A. rapacida* was the very long lateral spine of the scaphocerite as shown in his figures; our examination of the specimen shows the drawing to be inaccurate and we find this specimen to be *A. rapacida*.

BIOLOGICAL NOTES: This species appears to be a form that burrows in sandy to muddy bottoms. It has been collected as deep as 56 m. The specimens in our collections from Hawaii were from the intertidal region and were found in association with the gobiid fish *Psilogobius mainlandi* Baldwin. Dr. Randall of the Bishop Museum, Honolulu, Hawaii, caught this species in 2 metres of water near One Tree Island, Great Barrier Reef, in association with an, as yet to be identified, goby. We have no colour notes from Australian specimens but the specimens we have from Hawaii are almost transparent with widely dispersed red stellate chromatophores. The lateral margins of the carapace are delicately coloured with a shifting band of rainbow colours and the anterior portion of the carapace carry a sprinkling of lemon-green pigment spots. The eyes are pale violet and the eggs green. When a living specimen is twisted in the light the whole animal displays a delicate iridescence. Our largest Australian specimen is 57 mm in length.

AUSTRALIAN DISTRIBUTION. We have specimens from Shark Bay in Western Australia; in northern Australia from the Gulf of Carpentaria and from eastern Australia from One Tree Island in the Capricorn Group to Yamba, N.S.W.

GENERAL DISTRIBUTION: South Africa; Red Sea; Mediterranean coast of Israel (a migrant species through the Suez Canal — Steinitz, 1967:167); Singapore; Thailand; Vietnam; Indonesia and Hawaii.

Alpheus barbatus Coutière

Fig. 49

Alpheus barbatus Coutiére, 1897a:235; 1899: fig. 279, 280. De Man, 1911:387, fig. 88.

SPECIMENS EXAMINED: 1 specimen from AM P. 4103; 1, AM P. 5573.

DIAGNOSIS: Rostrum short, obtusely triangular, not reaching middle of visible part of first antennular article. Slight rostral carina reaching to posterior margin of orbital hoods; orbitorostral grooves shallow. Antennules stout, articles nearly equal in length, second antennular article only a little longer than broad. Stylocerite rounded distally, reaching near end of first antennular article. Scaphocerite with lateral tooth broad and straight, reaching well past end of antennular peduncles, squamous portion reaching just past end of peduncles. Carpocerite stout, 2.7 times as long as broad viewed laterally, reaching well past end of lateral tooth of scaphocerite. Basicerite without inferior tooth.

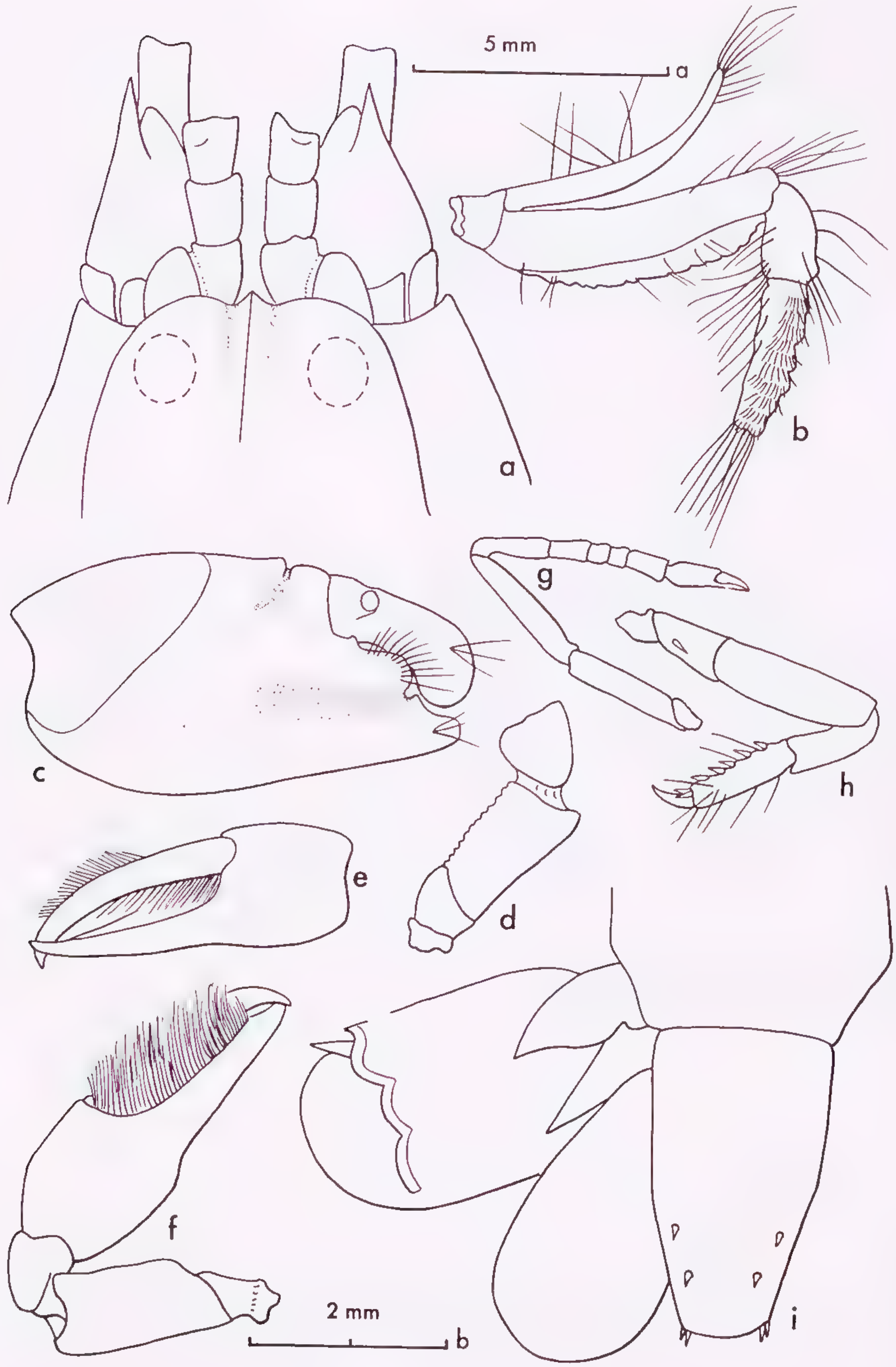

Fig. 49 *Alpheus barbatus* De Man
27 mm female from AM P. 5573. **a.** Anterior region, dorsal view; **b.** third maxilliped; **c, d.** large chela, lateral face and merus, medial face; **e, f.** small cheliped, lateral and medial faces; **g.** second leg; **h.** third leg; **i.** telson and uropods. c, d, e, f, g, h scale a; a, b, i scale b.

Articles of third maxilliped with ratio of: 10:3:5. Inferior margin of first article with series of low irregular protuberances. Setae on tip of second article few and not reaching middle of third article; setae on tip of third article not heavy and slightly more than half as long as article.

Large chela compressed, somewhat trapezoid, 2 times as long as broad with fingers occupying distal 0.3. Superior margin of palm bearing narrow and curving transverse groove proximal to dactylus. Inferior margin rounded without grooves or indentations. Lateral face with shallow longitudinal groove extending from near mid-palm to mid-pollex. Dactylus heavy, bulbous at tip. Merus 1.9 times as long as broad. Inferoexternal margin smooth, inferointernal margin rough without tooth distally; superior margin not projecting.

Small chela not sexually dimorphic, 2.6 times as long as broad, finger 1.7 times longer than palm which is as broad as long. Fingers gape, tips cross when closed. Proximal half of lateral face of dactylus bearing dense fringe of hair on cutting margin; medial face of both fingers with tufts of densely-set short setae on cutting margins that obscure fingers almost to tips.

Ratio of carpal articles of second legs: 10:5:2:2:5.

Ischium of third leg with spine, 0.4 as long as merus. Merus inermous, 3 times as long as broad. Carpus 0.6 as long as merus, superior margin projected into an obtuse tooth. Propodus 0.7 as long as merus bearing on its inferior margin 5 spines and a pair distally. Dactylus simple, conical, 0.4 as long as propodus.

Telson 2.7 times as long as posterior margin is broad. Dorsal spinules small and located in posterior third. Articulation of outer uropod in the form of 3 scallop-shaped flaps.

DISCUSSION: Our specimens compared well with the three syntypes of Coutière, now fragmentary, that we examined at the Muséum National d'Histoire Naturelle in Paris; these were also used by De Man for his expanded description (1911:387). The only difference is that the orbitorostral border in our specimens recedes slightly at the margins of the rostrum while this margin is straight and confluent with the rostrum in both Coutière and De Man's specimens; we do not regard this as important, especially with so few specimens known.

This species is easily recognized by the obtuse rostral triangle, by the trapezoidal shape of the large chela, and particularly by the thick tuft of hair that obscures the medial face of the fingers of the small chela.

BIOLOGICAL NOTES: Coutière's specimens were taken from 10 metres, but De Man's specimens were from the "coral reef". The collecting notes on the specimens from Australia gave no indication as to the type of habitat from which they were collected. Coutière stated that the colour was "*...rouge orange brilliant; les branchiostégites, l'espace sus-stomacal et toutes les soies sont d'un blanc opaque.*" Our specimens reach up to 27 mm in length.

AUSTRALIAN DISTRIBUTION: Both of our specimens came from North Queensland.

GENERAL DISTRIBUTION: Djibouti, Indonesia; we also have unreported specimens from East Africa and Christmas Island in the Indian Ocean.

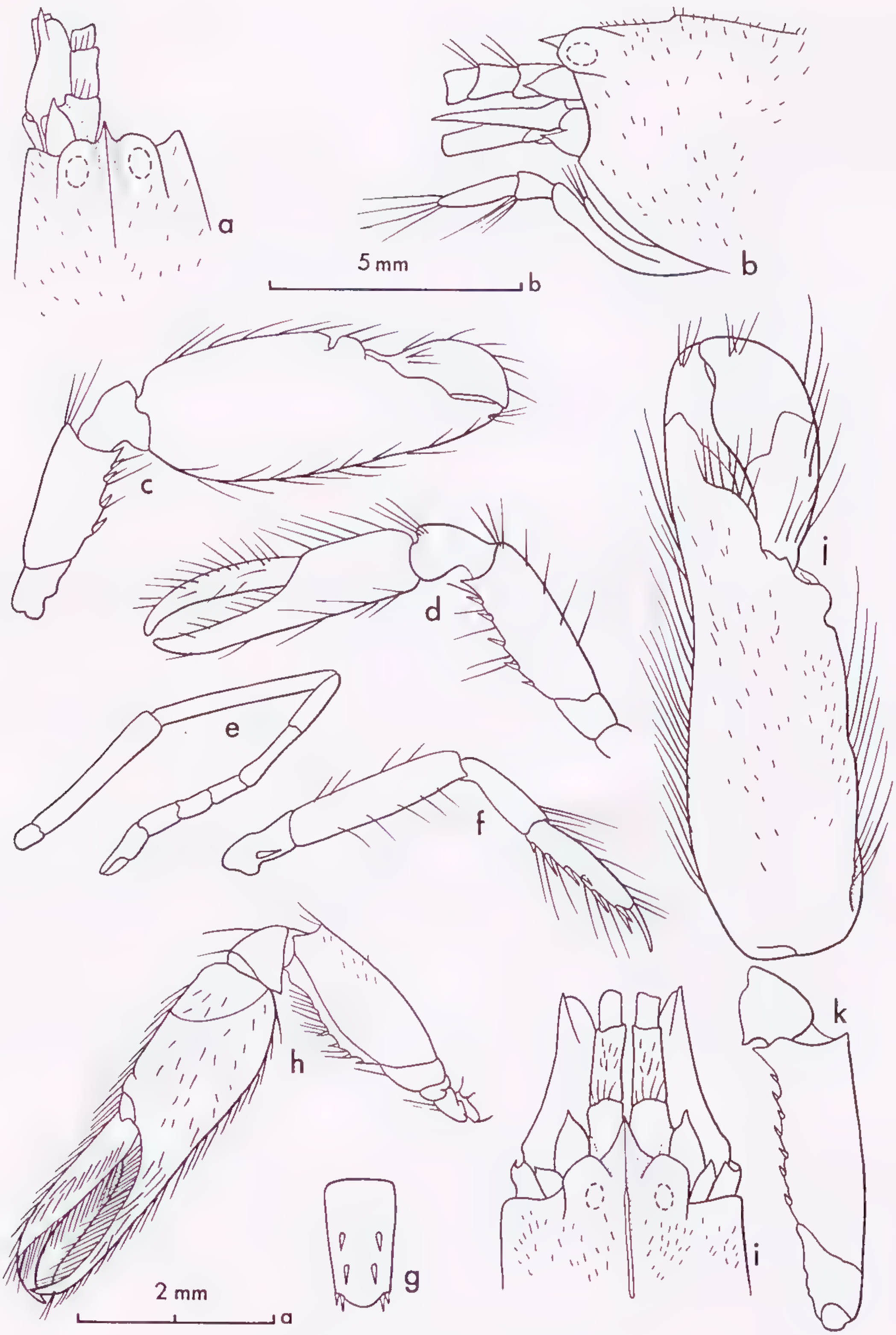

Fig. 50 *Alpheus pubescens* De Man
14 mm female from AM 121. **a, b.** Anterior region, dorsal and lateral view; **c.** large cheliped, medial face; **d.** small cheliped, medial face; **e.** second leg; **f.** third leg; **g.** telson; **h.** Small cheliped of male, lateral face (after De Man, 1911: fig. 89d). 34 mm male from BAU 27; **i.** Anterior region, dorsal view; **j, k.** Large chela and merus, medial face. a, b, c, d, e, f, g scale a; i, j, k, scale b.

Alpheus pubescens De Man
Fig. 50

Alpheus pubescens De Man, 1908:109; 1911:389, fig. 89. Tiwari, 1963:300, fig. 20.

SPECIMENS EXAMINED: 1 specimen from AM 121; (AM P. 27931); 1, BAU 27.

DIAGNOSIS: Carapace covered with a light pubescence of short stiff setae. Rostrum acute, reaching to middle of visible part of first antennular article, bearing rostral carina which is slightly concave between orbital hoods and continues to near posterior margin of hoods where it is interrupted and rises again as a crest continuing to mid-carapace. Margin between somewhat inflated orbital hoods and rostrum concave. Orbitorostral grooves moderately deep. Visible part of first antennular article and second article subequal; second article 1.6 times as long as broad, third article half as long as second. Stylocerite reaching to end of first antennular article. Squamous portion of scaphocerite reaching just past end of antennular peduncle, outer margin concave just proximal to lateral tooth; tooth directed slightly inward at tip and reaching well beyond squamous portion. Carpocerite as long as squame. Basicerite with acute tooth on inferior margin.

Second article of third maxilliped bearing a minimal brush of hairs distally on inferior margin of second article and a brush of moderately long hairs at tip of third article.

Large chela 2.7 times as long as broad with fingers occupying distal third. Superior margin with a transverse groove proximal to dactylus. Superior margin rounded and bearing towards medial side a sparsely set row of long forward-directed setae. Inferior margin also rounded and bearing setae similar to superior margin. Both dactylus and pollex with similar setae on superior and inferior margins. Merus 3 times as long as broad, superodistal margin not projected, inferointernal margin bearing 4 strong spines and an acute tooth distally.

Small chela sexually dimorphic. The dactylus of the male according to De Man (our male lacked this chela) is balaeniceps and the fingers are slightly longer than palm "... upper border which is flattened, with a transverse groove near dactylus and with the outer margin ridged; this chela is 3.45 times as long as high". Female chela in our specimen 4.5 times as long as broad and fingers are slightly longer than palm; inferior and superior margins carrying setae similar to large chela, and with a few setae on oppositive surfaces of fingers that cross. Carpus 0.3 as long as chela. Merus 0.7 as long as chela, inferointernal margin bearing 5 spines and an acute terminal tooth.

Carpal articles of second leg with ratio: 10:10:4:4:4.

Ischium of third leg with spine. Merus 5 times as long as broad, inermous. Carpus 0.5 as long as merus, superodistal margin terminating in a subacute tooth, inferodistal margin rounded. Propodus 0.6 as long as merus, bearing on its inferior margin 5 spines and a pair distally; both margins bearing scattered setae. Dactylus simple, 0.4 as long as propodus.

Telson 2 times as long as posterior margin is broad. Posterior margin arcuate and slightly projected; inner spines of posterior pair twice as long as outer. Dorsal spines equal in length to inner spines of posterior pair, anterior pair placed just anterior to midline.

DISCUSSION: We have been able to compare our 2 specimens to De Man's holotype and paratypes at the Zoologisch Museum in Amsterdam. The 14 mm female (AM 121) agrees well in general, although the small chela is heavier, 4.5 instead of 5.6 times as long as broad. The posterior portion of the rostral carina virtually disappears before the

mid-dorsal carina abruptly arises in this specimen, but in De Man's series this characteristic is variable. The other specimen (BAU 27) is 34 mm long and probably a male, but is badly mutilated, retaining only the large chela and one third leg. In it the rostral crest continues without interruption into the dorsal crest, the rostral triangle is much broader, the large chela more slender (fig. 50k) and the third maxillipeds are almost devoid of setae (we suspect these setae may have been broken off in collecting). In both specimens the pubescence of the carapace is slight (the 34 mm specimen also has light pubescence on the large chela), but we discovered that in the eight specimens of De Man this characteristic was variable, and even in the holotype the condition did not approach the impression given by De Man's figures. Tiwari found his specimens less hirsute than De Man's holotype.

BIOLOGICAL NOTES: The mutilated specimen was from dead coral in waters up to 10 feet deep; the other Australian specimen was without ecological data. De Man reported his specimens coming from 3 metres or less down to a possible 30 metres, from coral, "Lithothamnion", and dredged from various types of bottom. Tiwari's specimen was dredged from "coral rock".

AUSTRALIAN DISTRIBUTION: Both specimens came from the Torres Straits.

GENERAL DISTRIBUTION: Indonesia and Vietnam.

Alpheus miersi Coutière
Fig. 51

Alpheus rapax Miersi Coutière,1898d: 166, fig. 1.

Alpheus miersi Coutière, 1905a:903, fig. 42.

Alpheus gracilipes Miers, 1884:287. (*Nec* Stimpson, 1861)

Previous Australian records:
Miers, (*loc. cit.*). Port Molle, Qld., Flinders Is., Qld.

SPECIMENS EXAMINED: 2 specimens from BAU 46; 2, BAU 51; 1, JG 21-73.

DIAGNOSIS: Rostrum triangular, reaching to middle of first antennular article. Visible part of first antennular articles equal to third article. Second article a little longer than 2 times as long as broad. Stylocerite reaching to end of first antennular article. Scaphocerite with squamous portion reaching to end of antennular peduncle, lateral tooth a little longer; carpocerite as long as scaphocerite. Inferior margin of basicerite with acute tooth.

Ratio of articles of third maxilliped: 10:2:3.

Large chela subcylindrical, 3.2 times as long as broad with fingers occupying distal 0.4. Superior margin of palm bearing a small transverse groove proximal to dactylus, inferior margin smooth, slightly constricted opposite articulation of dactylus. Medial face of chela bearing a moderately dense sprinkling of setae, lateral face glabrous. Merus 2 times as long as broad; inferointernal margin slightly serrate bearing 3 spines and an acute tooth distally. Carpus cup-shaped, 0.4 as long as merus.

Small cheliped sexually dimorphic. Male chela (according to Coutière, we have only female specimens) 4.7 times as long as broad and fingers and palm are equal. Dactylus balaeniceps. Merus similar to female. Female chela 4.2 times as long as broad, fingers and palm equal. Dactylus not balaeniceps. Medial face of palm somewhat hirsute and lateral face glabrous. Merus 3.6 times as long as broad; inferointernal margin smoother than

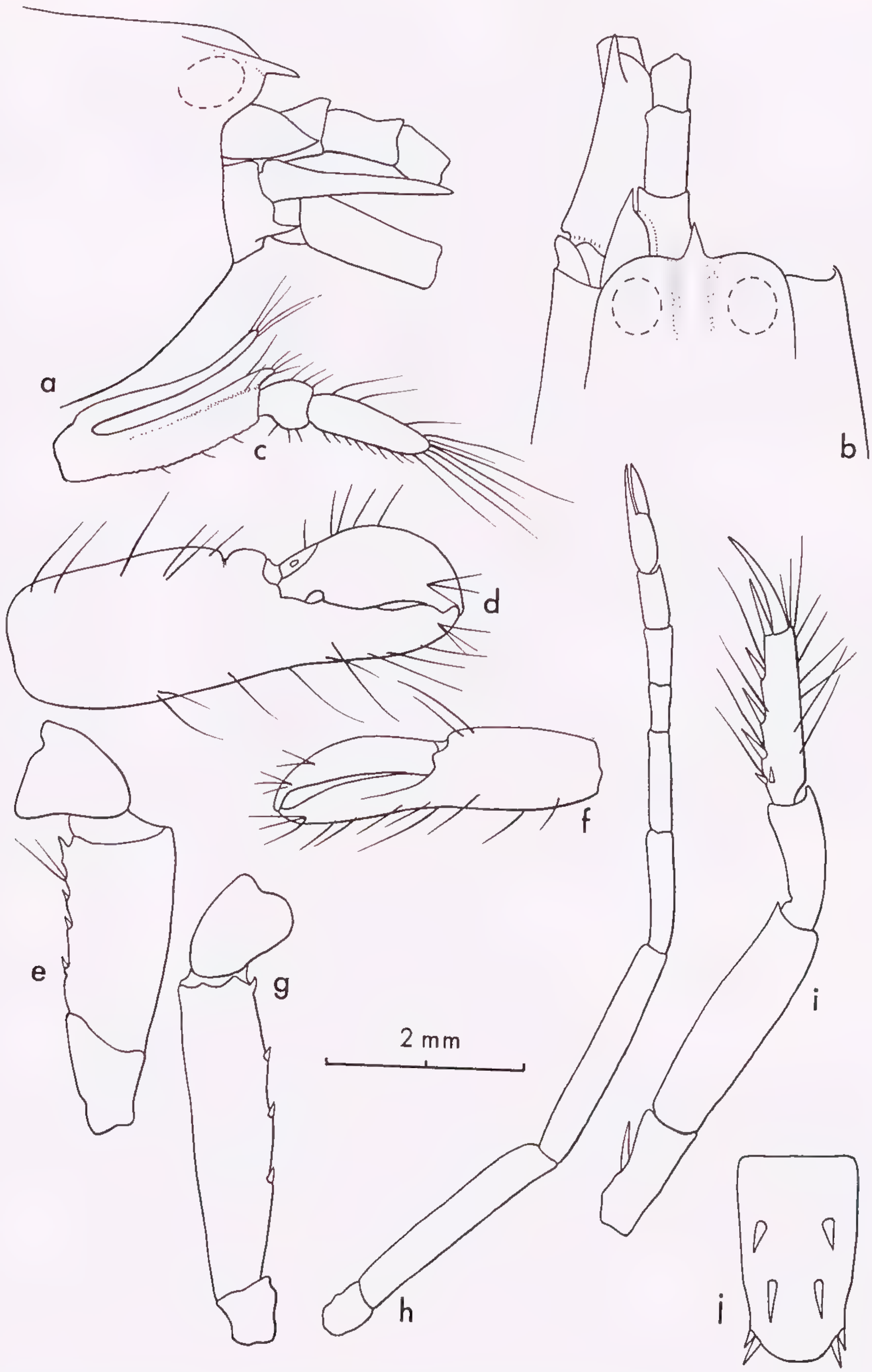

Fig. 51 *Alpheus miersi* Coutière
20 mm female from BAU 51. **a, b.** Anterior region lateral and dorsal view; **d, e.** third maxilliped, lateral face; **f, g.** small chela, lateral face and merus, medial face; **h.** second leg; **i.** third leg; **j.** telson. All figures same scale.

that of male but bears 3 similar spines and a small acute tooth distally.

Ratio of articles of second leg: 10:10:4:4:4.

Ischium of third leg bears strong spine. Merus 3.5 times as long as broad and bearing distally on inferointernal margin a small acute tooth. Carpus 0.5 as long as merus; inferior margin terminates distally in a subacute tooth; superodistal margin truncate. Propodus 0.7 as long as merus, bearing on inferior margin 5 spines and a pair distally. Dactylus slender, long, simple, 0.6 as long as propodus.

Telson 2 times as long as posterior margin is broad. Posterior margin only a little more narrow than anterior. Anterior pair of dorsal spines placed anterior to middle.

DISCUSSION: Coutière (1898d:166) was able to examine in the British Museum (Natural History) the two specimens from Australia that were collected by the **Alert** and reported by Miers (1884:287) to be *A. gracilipes.* Coutière decided they were different and gave them the name of *A. rapax Miersi.* He raised the subspecies to specific rank in 1905.

Our 4 specimens agree well with Coutière's description and figures (the types are missing) except for the merus of the third leg which in our specimens varies from 3.5-4.0 times as long as broad while in Coutière's specimens the merus is 5 times as long as broad. As this is often a variable character, with so few specimens we do not attach any significance to it. We have one specimen in our collections from the Indian Ocean in which the tooth on the merus of the third leg is missing.

BIOLOGICAL NOTES: Our specimens were collected intertidally. The specimens range in size up to 20 mm.

AUSTRALIAN DISTRIBUTION: Heron Is., Port Molle, Flinders Is., Lizard Is., Qld.

GENERAL DISTRIBUTION: Maldives and Laccadives; Ceylon; Indonesia; Philippines; Japan.

Alpheus brevirostris (Olivier)
Fig. 52

Palaemon brevirostris Olivier, 1811:664, pl. 319, fig. 4.

Alpheus brevirostris Milne-Edwards, 1837:350. Haswell, 1882b:187. Coutière, 1899:93, 230, figs. 61, 281 (anterior region of carapace and large chela of type).

Nec Alpheus brevirostris De Man, 1888b:261 and 1897:757 (both = *Alpheus rapax* Fabricius); 1902:877 (=?); 1907:427 (= *Alpheus distinguendus* De Man). (For synonymy of this and related species see De Man, 1909b:146, *et seq.*; he does not mention the true identity of his 1902 specimen.)

Nec Alpheus brevirostris Ortmann, 1890:479 (= *Alpheus djeddensis* Coutière).

Nec Alpheus brevirostris Coutière, 1898h:249, fig. 1 (= Alpheus distinguendus De Man).

?*Alpheus brevirostris* Lenz, 1905:384. (Specimen fragmentary, identity uncertain).

SPECIMEN EXAMINED: Holotype and only specimen known, male of 50 mm from "New Holland" through the courtesy of the Museum National d'Histoire Naturelle, Paris.

DESCRIPTION: "Palaemon with rostrum short, acute, simple; left chela large,

compressed, smooth." (Olivier, *loc. cit.* Translated from the Latin by the authors).

"It resembles the two preceding species *(P. diversimanus* and *P. bidens,* now *Alpheus).* The *corcelet* (carapace) is smooth, rounded nearly cylindrical. The rostrum is very short, simple, acute. The eyes are small, rounded and fixed. The external antennae are of the length of the body. The external scale which accompanies them (scaphocerite) is strongly ciliated on its internal border and is terminated by a strong and acute spine on its external border. The interior antennae are terminated by a small setiferous filament. The anterior pair of legs are (in the form of) unequal and very large pinchers; the left is larger than the right. The hand is very large, compressed, smooth on its two sides, with both upper and lower margins sharp and a little hairy. The movable finger is broad, compressed, rounded and hairy on its external border, less rounded on its internal border and provided with a molar tooth at its base. The inferior finger is excavated at its base to receive the molar tooth of the other finger. It is distally arched and a little sharp up to its tip. The fingers of the left (= right?) chela are simple, very long, a little arched at their extremity, strongly hairy on their inner side. The second feet are very small, a little longer than those that follow, and terminate in chelae. The superior scale of the tail (= telson) is broad, supplied with four spines on its superior surface, strongly setiferous on its extremity.

"It is found on the coasts of New Holland, from where it was collected by the late Péron." (Olivier, *loc. cit.* Translated from the French by the authors.)

To this description H. Milne-Edwards adds: (1) the anterior margins of the oribital hoods are rounded and without spines. (2) The second article of the antennular peduncle is more than twice as long as the first. (3) The scaphocerite tapers towards its tip and is pointed; it exceeds the length of the antennular peduncles. (4) Third maxillipeds are slender and reach well beyond the end of the scaphocerite. (5) The large cheliped carries on its superior margin two small crests, but none on its external face, but the inferior margin is almost sharp and is terminated by the pointed fixed finger, which carries at its base a circular cavity to receive the tubercle of the movable finger; the dactylus is very compressed and very obtuse at its tip. (6) The fingers of the small chela are very long, slender, punctate and a little curved and bearing hairs on their prehensile (oppositive) faces, and gape when closed. (7) The merus bears an acute spine on the superior margin, but it is not quite at the extremity (*"si ce n'est tout à fait a son extrémité"*). Length, 2 inches *(pouces).* It is evident that Milne-Edwards had no additional specimens and was describing the holotype established by Olivier.

DISCUSSION: In 1909, after over twenty years of lengthy concern about certain species in the Brevirostris group, De Man finally compared the holotype of *A. brevirostris* with the specimen De Haan had listed from Japan as *A. rapax* Fabricius. He decided that none of the specimens he had called variously *A. brevirostris* or *A. rapax* were like that of Olivier's, and to this different form he applied the name *A. distinguendus.* He also rejected Coutière's contention (1899:14, 1905a:905) that *A. rapax* was a synonym of *A. brevirostris*. De Man stated that he found that the tooth of the stylocerite was directed outward in *A. brevirostris,* but straight ahead in *A. distinguendus.* He also found that in *A. brevirostris* the carpocerite was much shorter than the scaphocerite and reached only to the end of the middle article of the antennular peduncle, while the scaphocerite itself reached two-thirds of the length of the distal article of the antennular peduncle beyond that article. In contrast, he stated that in *A. distinguendus* the carpocerite and the scaphocerite were equal and both passed the end of the antennular peduncle by one-third the length of the last article. He also found that the transverse groove behind the dactylar articulation of the large chela present in *A. brevirostris,* was lacking in *A. distinguendus,* and also that the surface in *A. brevirostris* was smooth, and definitely

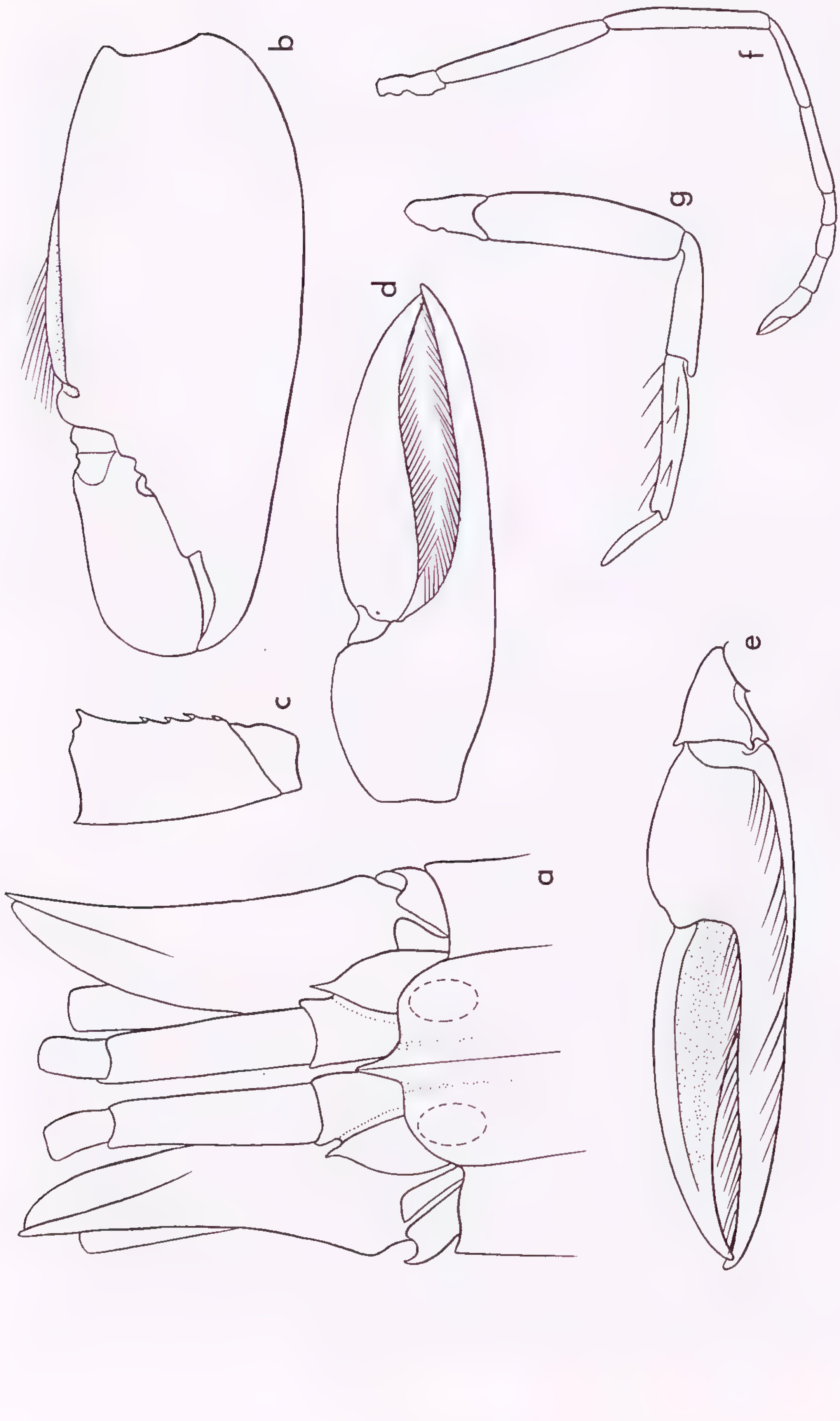

Fig. 52 *Alpheus brevirostris* (Olivier)
Holotype of Olivier, a 50 mm male from "New Holland". **a.** Anterior region, dorsal view; **b, c.** large cheliped, chela lateral face, merus medial face; **d, e.** small chela, lateral and medial face; **f.** second leg; **g.** third leg. All figures same scale.

granular in *A. distinguendus*. Finally, he found that the dactylus of the small chela (both specimens were males) to be two-thirds as wide at its base in *A. distinguendus* as it was in *A. brevirostris*.

We have re-examined the type specimen of *A. brevirostris* through the courtesy of the Muséum National d'Histoire Naturelle of Paris and found it to be in surprisingly good condition considering its age. We did not examine the specimen that De Hàan regarded as *A. rapax* and that De Man later used as his type for *A. distinguendus* (but did not so specify). In *A. brevirostris* it is true that the stylocerite does turn slightly outward, but to this characteristic we do not attach great significance. We are at loss to understand De Man's description of the relative lengths of the antennular and antennal peduncular articles, for in Olivier's specimen the carpocerite reaches almost to the end of the antennular peduncle and in the specimens we have identified as *A. distinguendus* from Australia, the relative lengths of the three parts are both variable and similar, in general, to Olivier's type. As the breadth of the dactylus of the small chela usually varies with sex and also maturity of the specimen, again we attach no great significance to the slight differences cited by De Man.

The only reliable characteristic for separation of *A. brevirostris* from the form we have identified as *A. distinguendus* in Australian waters is the form of the large chela. In the holotype for *A. brevirostris* two small carina, almost merely angles, run along the superior margin towards the articulation of the dactylus, leaving a triangular flattened area between them. Just proximal to the dactylus these carinae and the flattened area is cut by a slight but definite transverse groove. In the form that we have identified as *A. distinguendus* the carinae and the flattened area occurs, but instead of a transverse groove the carinae terminate at the position where the groove would occur with small, rounded shoulders. The second characteristic which is plainly mentioned by Olivier is that the surface of the chela in *A. brevirostris* is smooth *(laevi)*, while De Man states that in *A. distinguendus* it is definitely *"plus grossierement granuleuse"* than in *A. brevirostris*. We have compared our specimens of *A. distinguendus* of equal size to Olivier's holotype and find the large chelae are definitely granulose, particularly on the medial surface.

These appear to be the only differences between Olivier's holotype and *A. distinguendus*. The unique form of the small chela, excavate and setiferous on opposing surfaces of the medial face, the ratios of the carpal articles of the second legs, the subspatulate condition of the third legs, even such minor points as the armature of the meri of the chelipeds and the heavy rounded distosuperior lobe of the carpus of the third legs are identical. But none of the specimens available in the collections had the transverse groove, or even approached it.

Olivier's specimen was collected by Péron from "New Holland" and might have been from most anywhere that Péron visited, from near Sydney around southern and western Australia to Melville Island on the northern coast (see discussion under *A. villosus* p. 52). Our records for *A. distinguendus* run from near Perth, W.A. around the western, northern, and eastern coasts to Botany Bay, N.S.W. We suspect that somewhere, possibly out of our recorded range for *A. distinguendus* a population will be found in which these characteristics are variable and some specimens will be found with a large chela with the transverse groove and smooth surface characteristic of the true *A. brevirostris*. Until that happens, we reluctantly consider the two forms as separate species; when such a population is found, *A. distinguendus* will be the junior synonym of *A. brevirostris*.

Without any specimens of this species, we are not considering the validity of *A. brevirostris var. angustodigitus* that De Man described from the coast of Borneo. It should

also be noted that Coutière considered *A. digitalis* De Haan from Japan to be a species erected on the basis of an anomalous form of a regenerating large chela, which he then put into synonymy under *A. brevirostris* (1898h:429); while De Man did not specifically list Coutière's citation of the name in synonymy under *A. distinguendus,* he evidently so considered it (see quotation below).

AUSTRALIAN DISTRIBUTION: "New Holland".

GENERAL DISTRIBUTION: It is difficult to follow the changes of names produced by De Man and other workers of his time in the complex of *A. brevirostris, A. rapax, A. distinguendus,* but De Man, 1911:386 summarizes: "The typical *A. brevirostris* from New Holland is . . . only known . . . from Olivier's type for this rare species has seemingly not yet been found back since it was described in the Encyclopaedie Méthodique."

Alpheus rapax Fabricius
Fig. 53

Alpheus rapax Fabricius, 1798:405. De Man, 1909b:147, pl. 7, figs. 1-8.
Alpheus malabaricus Hilgendorf, 1878:832. (*Nec* Fabricius, 1798.)
Alpheus brevirostris De Man, 1888b:261; 1897:757. (*Nec* Olivier, 1811.)
Nec Alpheus rapax De Haan, 1850:177, pl. 45, fig. 2 (= *Alpheus distinguendus* De Man).
Nec Alpheus rapax Bate 1888:155, pl. 99, fig. 1 (= *Alpheus rapacida* De Man).
Nec Alpheus rapax De Man, 1888:264 and 1892:404 (both = *Alpheus distinguendus* De Man).
Nec Alpheus rapax Ortmann, 1890:481 (= *Alpheus distinguendus* De Man).
Nec Alpheus rapax Coutière, 1905a:905 (=?, according to De Man, 1909b:155).
?*Alpheus rapax* Boone, 1935:142, pl. 37.
?*Alpheus rapax* Ledoyer, 1970:126, pl. 12.

SPECIMENS EXAMINED: 1 specimen from AM 92 (AM P. 27762); 2, AM 172 (AM P. 27542); 1, AM 287 (AM P. 27543); 1, AM P. 8794; 1, JC 12; 1, JC 14.

DIAGNOSIS: Rostrum acute, reaching variously from first quarter of visible part of first antennular article to end of that article. Rostral carina, high and narrow, reaching posteriorly to base of orbital hoods. Orbital hoods inflated, forming deep orbitorostral grooves. Antennular peduncles slender, second article 2.2-2.7 times as long as broad, twice as long as visible part of first and third articles. Stylocerite with tooth reaching nearly to end of first antennular article. Outer margin of scaphocerite and first and second antennular articles with fringe of setiferous bristles. Scaphocerite with lateral margin slightly concave, squamous portion broad and reaching a little beyond antennular peduncles with lateral tooth a little longer. Carpocerite reaching to end of antennular peduncle. Basicerite with acute tooth on inferior margin.

Third maxilliped with ratio of articles: 10:3:8; distal end of second article bearing a group of long hairs reaching to and beyond tip of third article; third article with long hairs at tip.

Large chela compressed, 2.8 times as long as broad with fingers occupying distal 0.4. Superior margin flattened with transverse groove proximal to dactylus, medial edge of flattened area bearing row of long forward-sweeping hairs, lateral edge also bearing a similar row of shorter hairs. Inferior margin flattened on palmar portion, knife-like in distal section and bearing a row of forward-sweeping hairs that extends to tip of propodal finger. Opposite articulation of dactylus, lower margin with slight constriction. Dactylus

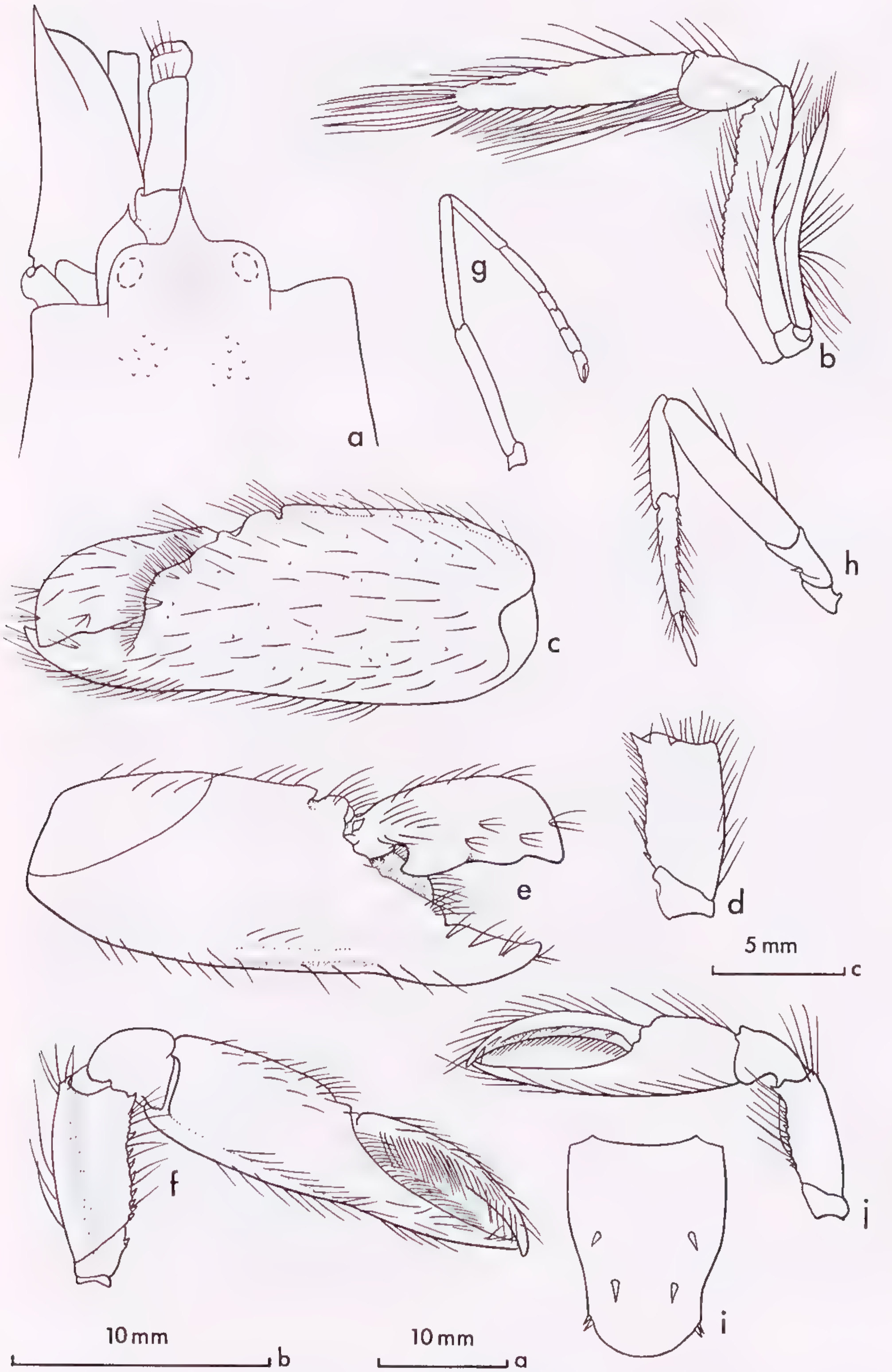

Fig. 53 *Alpheus rapax* Fabricius
70 mm male from AM 92. **a.** Anterior region, dorsal view; **b.** third maxilliped, medial face; **c, d.** large chela and merus, medial face; **e.** large chela, lateral face; **f.** small cheliped, medial face; **g.** second leg; **h.** third leg; **i.** telson. 34 mm female from AM P. 12949 (from Indonesia, no further data). **j.** Small cheliped, medial face. c, d, e, f, g, h scale a; a, b, i scale b; j scale c.

bearing long forward-sweeping hairs similar to propodal finger; plunger of dactylus of minimal development.

Small chela never balaeniceps, but with some sexual differentiation (*cf*. fig. 53f and j), highly compressed, over 4 times as long as wide with fingers 1.8 times as long as palm. fingers with opposing faces fringed with dense row of bristles, both fingers strongly curved at tip. Superior and inferior margin bearing forward sweeping hairs particularly in dactylar region. Merus similar to that of large chela.

Carpal articles of second leg with ratio: 10:(7-10):3:3:5.

Ischium of third leg with small spine. Merus 4.5 times as long as wide, inermous. Carpus 0.4 as long as merus, superodistal margin projected as rounded tooth. Propodus 0.7 length of merus and bearing on inferior margin 3-7 small spines with a pair distally. Superior and inferior margins bearing long sparsely-set hairs. Dactylus spatulate, slightly excavate on ventral surface.

Telson 2.5 times as long as posterior margin is broad, posterior margin strongly arcuate.

DISCUSSION: We do not have enough specimens from Australia to define the limits of variation in this extremely variable species in these waters. However, from our more extensive Thai collections the following variations were observed: The rostrum reached variously from the first third of the visible part of the first antennular article to the end of that article. The second antennular article varied from 2.0 to 3.5 times as long as broad. The flattened areas of the superior and inferior margin of the large chela were at times rounded. The first and second carpal articles of the second legs varied from 0.7-1.0 times the length of the first. The fingers of the small chela were sometimes only a little longer than the palm and sometimes were almost twice as long as the palm. The fringes of setae on the opposing faces of both fingers varied with size and sex of the specimen, being of minimal development in small specimens and very dense in large males; these males never reach the true balaeniceps condition.

We feel the specimen Ledoyer figured (1970:pl. 12) is probably not *A. rapax* since the large chela does not have a transverse groove and the dactylus of the small chela far exceeds the propodal fingers which is not typical for *A. rapax*. However, as Ledoyer pointed out, it is a small specimen (15 mm) and possibly its aberrant appearance is the result of immaturity. We do not believe Boone's specimens from Queensland (*loc. cit.)* to be *A. rapax*. She stated that the fingers of the small chela were "... armed on the inferior lateral margin with a double longitudinal series of six pairs of acuminate spines; the dactyl is two-fifths as long as propodus, curved, thickish, with a strong pointed tip". We feel this implies that the dactylus of the third leg was not spatulate. Also she stated that the telsal margin was truncate. These characters are not typical of *A. rapax*. Further, her specimens were all taken from coral rather than the typical bottom dwelling habitat of *A. rapax*. We have been unable to examine the specimens at the Vanderbilt Marine Museum, and without this examination, we cannot assign the specimens to their correct species. The synonymy (above), except for Bate's and Boone's reports, is that of De Man (1909b:147).

BIOLOGICAL NOTES: This species is a bottom dwelling form, found largely intertidally on sandy bottoms. However, De Man's 2 specimens from Indonesia were reported from 46 m on "stony bottom". We have observed it in many places associated with a gobiid fish. In Hawaii it is known to be associated with *Psilogobius mainlandi* Baldwin (Moehring 1972). Yaldwyn supplies the following colour notes for the specimen we have figured: "Irregular banding of green on carapace and abdomen, hands with

irregular green bands across upper surface, some blue on fingers and legs" Hawaiian specimens have similar banding. We have noted that the diffuse manner of the banding gives an excellent protective coloration on the sandy substrate. Specimens range in size up to 70 mm.

AUSTRALIAN DISTRIBUTION: We have specimens from Clarence Straits and the Gulf of Carpentaria in northern Australia and from near Townsville, Qld..

GENERAL DISTRIBUTION: South Africa; East Africa; Madagascar; Red Sea; Maldive Archipelago; Ceylon (Sri Lanka); Mergui Archipelago; Singapore; Indonesia; Thailand; Japan; Mariana and Marshall Islands and Hawaii.

Alpheus moretensis sp. nov.
Fig. 54

HOLOTYPE AND SOLE SPECIMEN: 28 mm male from 27°10′ S; 153°21′ E. 8 fathoms, Moreton Bay. (UQ 35). AM P.30802.

DIAGNOSIS: Rostrum acute, reaching to last quarter of visible part of first antennular article, with rostral carina high and narrow, concave between the orbits and extends to middle of carapace. Anterior margins of carapace slightly concave at base of rostrum. Orbital hoods inflated, forming narrow deep orbitorostral grooves. Carapace smooth, not punctate nor pubescent. Second antennular article 3.3 times as long as broad, 2 times as long as visible part of first article, third article 0.4 as long as second. Stylocerite acute, reaching to near end of first antennular article. Scaphocerite with squamous portion as long as antennules, lateral tooth a little longer. Carpocerite as long as lateral tooth of scaphocerite. Basicerite with small acute tooth on inferior margin.

Ratio of articles of third maxilliped beginning with base: 10:3:6. Setae of distal end of inferior margin of second article not long. Tip of last article with tuft of long setae.

Large chela 2.8 times as long as broad with fingers occupying distal 0.46. Superior margin flattened and bearing deep transverse groove proximal to dactylus. Superior margin bearing a sparse row of setae toward medial face. Inferior margin without grooves, rounded, not knife-edge, and bearing toward medial face moderately long setae that sweep forward and upward. Setae on pollex and dactylus less dense than on palm. Surface of palm and proximal part of pollex granular, dactylus smooth. Plunger of dactylus a low crest. Merus 2.3 times as long as broad; inferointernal margin with 6 spines, fine irregular dentition and with an acute distal tooth. Inferoexternal margin also with minute dentition. Carpus 0.4 as long as merus.

Small chela of male 4.4 times as long as broad with fingers balaeniceps and 1.3 times longer than palm. Tips of fingers cross when closed without leaving a gape. Superior margin of palm with slight transverse groove proximal to dactylus. Superior and inferior margin beset with hairs similar to that of large chela. Merus 2.2 times as long as broad with margins similar to that of large cheliped. (Female chelae unknown).

Carpal articles of second legs with ratio: 10:10:4:4:4.

Only one thoracic leg present, possibly fourth. Ischium with spine; merus 5.8 times as long as broad, inermous. Carpus 0.7 as long as merus with superodistal margin projected as a subacute tooth. Propodus 0.8 as long as merus, bearing setae on both margins with those of superior margin set in tufts; six spines on lateral face and a pair of spines on inferodistal angle. Both inferior and superior margins bearing many fine setae, those of superior margin set in clusters of 3 or 4 setae. Dactylus spatulate, 0.3 as long as propodus.

TABLE 4
The separation of *A. moretensis* from related species

	A. moretensis sp.nov.	*A. djeddensis* Coutière	*A. djiboutensis* De Man	*A. pubescens* De Man	*A. savuensis* De Man	*A. miersi* Coutière	*A. platyunguiculatus* (Banner)
Carapace punctate or pubescent	No	Yes	Yes[1]	Yes	No	No	No
Dorsal carina to mid-carapace	Yes	No	No	Yes	No	No	No
Transverse groove on palm of small chela, male	Yes	Yes	No	Yes	No	No	No
Second leg: ratio of first two carpal articles	10:10	10:7	10:7	10:15	10:15	10:11	10:27
Third leg:							
tooth on merus	No	No	No	No	No	Yes	No
dactylus spatulate	Yes	No[2]	Yes	No	No	No	Yes

1. Variable, but usually to some degree
2. Variable, but not greatly broadened

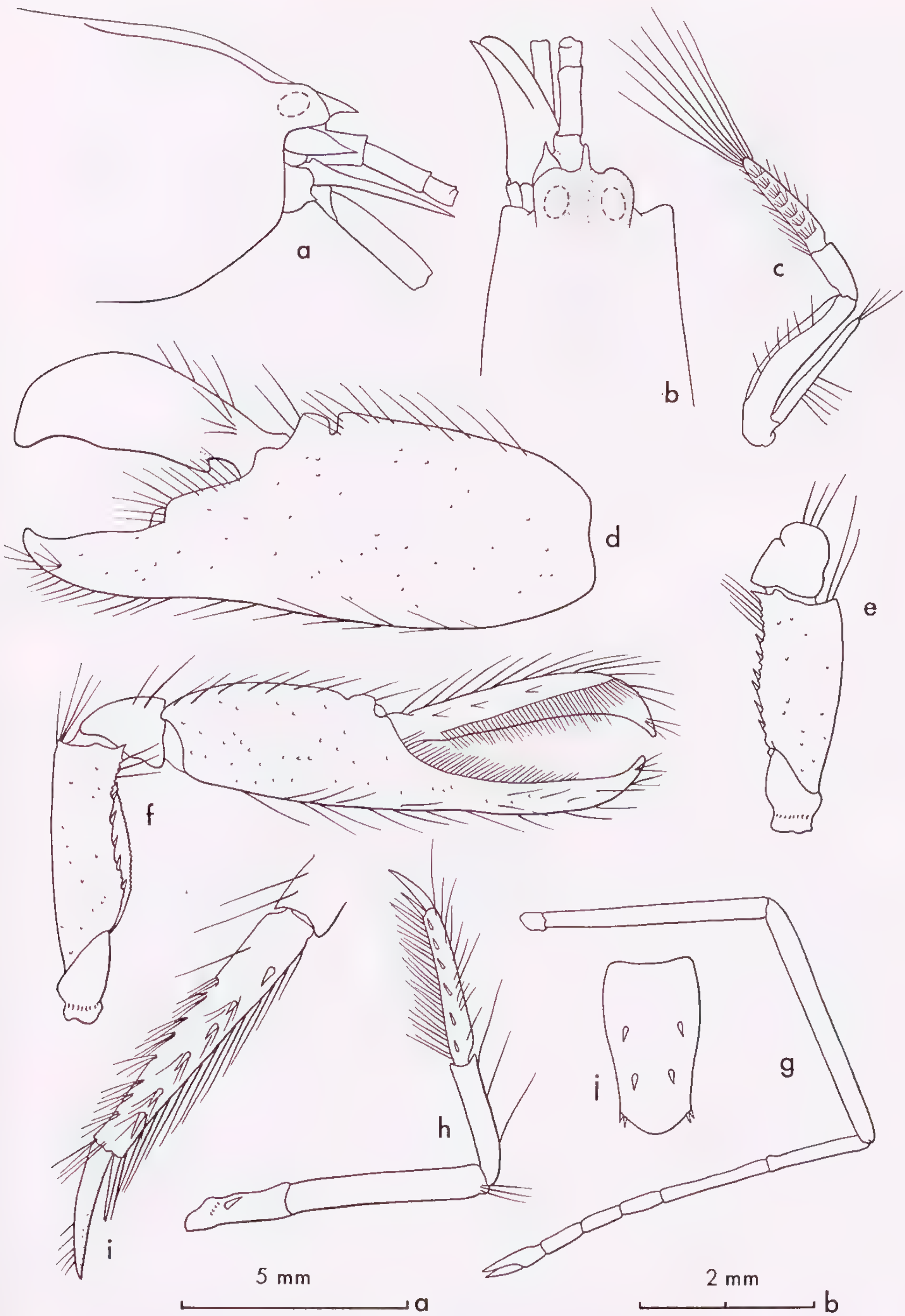

Fig. 54 *Alpheus moretensis* sp. nov.
Holotype (male). **a, b.** Anterior region, lateral and dorsal view; **c.** third maxilliped; **d, e.** large chela and merus, medial face; **f.** small cheliped, medial face; **g.** second leg; **h, i.** fourth leg (?) and enlarged propodus and dactylus; distal region; **j.** telson. a, b, c, d, e, f, g, h, j scale a; i scale b.

Telson 2.5 times as long as posterior margin is broad. Posterior margin arcuate and projecting well beyond tips of posterolateral spines. Anterior pair of dorsal spines placed anterior to middle.

DISCUSSION: It is unfortunate that this is a sole specimen and lacking all but one of the walking legs. It does have enough parts, however, to place it firmly in the Brevirostris Group, and to separate it from other species within that group. The transverse groove proximal to the dactylar articulation of the large chela and the presence of a balaeniceps dactylus on the small chela of this male are rather firm characteristics that relate to a number of species, from which it can be separated by the characteristics given in Table 4. (*Alpheus platyunguiculatus* Banner has been included in the table, but in it the small chela of the male is of sub-balaeniceps form.) There are also differences amongst these species in the proportions of the chelae and of the articles of the third legs.

The specimen was "collected over sand" in 8 fathoms and probably has a habitat similar to *A. stephensoni* Banner and Smalley. Nothing is known of its colour in life.

The name is derived from the locality of its capture, with a syllable dropped for euphony. The holotype will be placed in the Australian Museum.

Alpheus djiboutensis De Man
Fig. 55

Alpheus djiboutensis De Man*, 1909b:160, pl. 7, fig. 17-24. Holthuis, 1958:25, fig. 9.

SPECIMENS EXAMINED: 2 specimens from JR1; 2, JR2; 1, JR3; 2, JR4; 1, JR12.

DIAGNOSIS: Rostrum subacute reaching near end of first antennular article, with strong carina that reaches slightly posterior to orbital hoods, orbitorostral grooves moderately deep. Orbitorostral margin confluent with rostrum, without indentation. Carapace somewhat granular. First and third antennular article subequal, half as long as second antennular article which is 1.7 times as long as broad, lateral margin of first and second article beset with short, setiferous bristles. Stylocerite acute, not reaching end of first antennular article. Lateral margin of scaphocerite concave; lateral tooth strong, reaching well beyond antennules; squamous portion narrow, reaching end of antennular peduncle. Carpocerite stout, reaching end of antennular peduncle. Basicerite with inferior margin bearing small acute tooth.

Second article of third maxilliped a little longer than broad, bearing distally on inferior margin small tuft of long fine setae. Third article 4 times as long as broad, margins with many long hairs, distal tip with brush of long hairs.

Large chela 2.5 times as long as broad. Superior margin somewhat flattened, bearing narrow transverse groove proximal to dactylus and on either side of flattened area a row of forward-sweeping hairs, hairs on medial margin longer than lateral. Inferior margin bearing a row of long hairs that are directed forward and medially. Medial face granulate, lateral face less so. Dactylus truncate, plunger of minimal development. Merus 2.5 times

*In an annotated checklist of the alpheids of the Red Sea, now (November, 1978) in preparation, we will review the separation of *A. duboutensis* De Man 1909b from *A. djeddensis* Coutière 1897e, and will conclude that with the inherent variation in this species the distinction between these two nominate species is invalid. When the Red Sea paper is published, all references to *A. djiboutensis,* including this reference, will be placed in synonymy. It should be noted that although *A. djeddensis* has appeared only three times in the literature (the original description, two passing references and one figure in Coutière's thesis (1899) and a mention by De Man in his description of *A. djiboutensis),* Article 23b of the 1964 *International Rules of Zoological Nomenclature . . .* which permitted an unused or forgotten name to be considered a *nomen oblitum* was deleted by the XVIIth International Congress of Zoology, Monaco (see Bull. Zool. Nom. 31(2): 79.)".

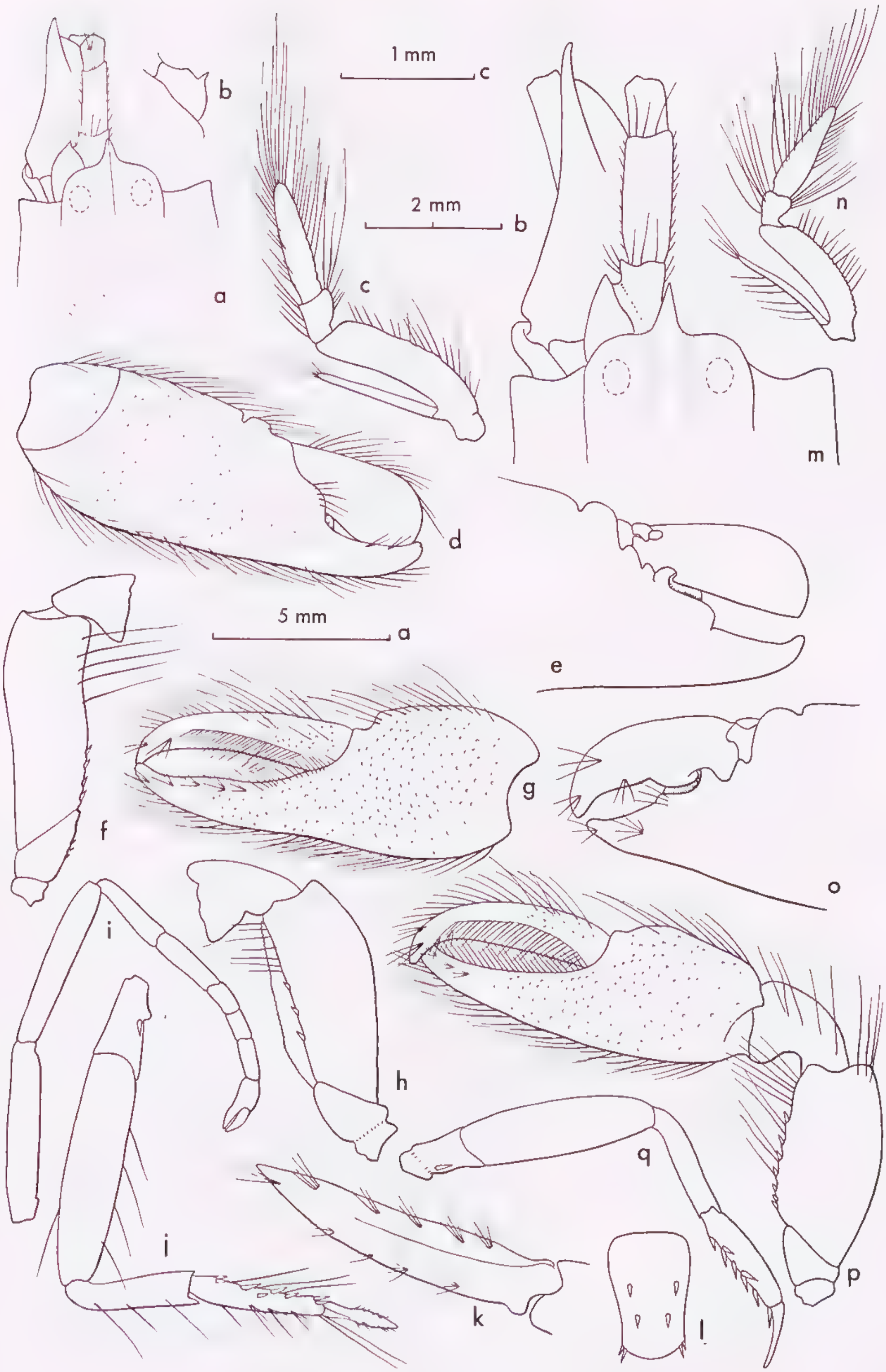

Fig. 55 *Alpheus djiboutensis* De Man
36 mm male from JR 2. **a.** Anterior region, dorsal view; **b.** basicerite; **c.** third maxilliped; **d, e.** large chela and distal end, medial face; **f.** merus of large cheliped, medial face; **g, h.** small chela and merus, medial face; **i.** second leg; **j, k.** third leg and enlarged dactylus superior face; **l.** telson. 32 mm male from JR 3. **m.** Anterior region, dorsal view; **n.** third maxilliped; **o.** anterior region of large chela, lateral face; **p.** small cheliped, medial face; **q.** third leg. a, b, c, d, e, f, g, h, i, j, l, o, p, q scale a; m, n, scale b; k scale c.

as long as broad, inferointernal margin bearing only several long setae distally but more proximally bearing several small spines. Inferoexternal margin serrate. Inferior margin of ischium also dentate, sometimes bearing a few spines.

Small chela of both sexes 2.7 times as long as broad, with fingers slightly longer than palm; margins of palm and fingers bearing long setae. Dactylus of male sub-balaeniceps, not markedly broadened with setiferous crests not joining over distosuperior surface, occasional old, large females similar. Merus similar to that of large chela.

Ratio of articles of second legs: 10:8:3:3:4, with first article varying from slightly longer to slightly shorter than second article.

Ischium of third leg with spine. Merus inermous, 4 times as long as broad. Carpus a little more than half as long as merus, distoinferior margin projecting as obtuse tooth, distosuperior margin as small acute tooth. Propodus 0.6 as long as merus, bearing on its inferior margin 7 spines with a pair distally. Dactylus 0.5 as long as propodus, slightly broadened in middle and flattened on inferior surface; superior surface convex, with longitudinal ridge in middle and bearing small patches of setae near outer edges.

Telson 2 times as long as posterior margin is broad, anterior pair of dorsal spines placed anterior to middle.

DISCUSSION: In addition to the specimens collected by Dr J. E. Randall listed above, for this species we have several specimens from the following archipelagoes or areas: Elat and the Sudanese coast, Red Sea; coast of Tanzania; Aldabra Atoll; Ceylon; Ambon, Indonesia; New Guinea; Solomon Islands; Marshall Islands; Fiji Islands; Society Islands. All were collected by ichthyologists who were studying goby-shrimp symbiotism and most were collected by Dr Randall who also supplied us with colour transparencies of the freshly caught shrimp (often speared with a small multipronged spear). Others were supplied by Dr L. Karplus, D. B. E. Magnus, N.V.C. Polunin, and M. Tsurnamal. In our study we were reminded of the statment of Chace (1972:66); "Several species of the Brevirostris Group, to which *A. floridanus* belongs, are so variable that they should be popular with those biologists who would deny the species concept."

We should note in passing that while this species of alpheid is the one most studied in the shrimp-goby association, *A. rapax* Fabricius, *A. distinguendus* De Man and *A. rapacida* De Man are also in our collections with reports of such association. Further, from Japan Miya and Miyake (1969:307) have described a new species, *A. bellulus*, and Takagi (1966:83) lists *A. brevicristatus* De Haan also as in the same type of association. In the Atlantic Randall has remarked that the goby *Nes longus* (Nichols) of the Caribbean "shares a burrow in the sand with an indefatigable snapping shrimp" (Randall, 1968:247). The shrimp has since been identified as *A. floridanus* Kingsley by Dr F. A. Chace Jr. at the National Museum of Natural History, Washington D.C. (Randall, personal communciations).

All of these shrimp are of the Brevirostris Group. There is one species, however, in the Edwardsii Group that has been reported with similar associations. MacNae (1957:361) reporting from South Africa, Thomassin (1971:381) from Madagascar and Farrow (1971:487) from Aldabra Atoll, have reported *A. lobidens* De Haan (as *A. crassimanus* Heller) living in burrows in association with a goby. Certainly *A. lobidens* is not an obligate commensal, for we have collected it in rather great number throughout the Indo-Pacific and have never noticed a goby near or in its burrow.

The gobies of the association have been reported to belong to several genera and a number of species — Karplus *et al.* (1974:259) report 6 species in 4 genera in the northern

Red Sea alone. Dr Randall believes that some of the species he has captured with alpheids have not yet been named (personal communication).

Like Dr Chace with his *A. floridanus,* we have observed much variation in this species. Some of the major differences are:

1. Anterior carapace. The anterior margin varied from where the curve reaching to the rostrum started at the middle of the orbital hoods and reached almost to the middle of the rostral projection to where the orbitorostral margin curved slightly posteriorly at the edge of the orbital hoods before joining the rostral base (as shown in figs. 55a and m). The rostral carina varied from moderately sharp to rounded.

2. Surface of the carapace. De Man described and figured the carapace of his specimen from Djibouti having large punctations laterally and a smooth area on the midline. In none of our specimens were the punctations as coarse as those figured by De Man, and in some this sculpturing was scarcely discernible. In 2 specimens we could detect a light pubescence.

3. Third maxillipeds. Three of the Australian specimens carried a brush of long hairs on the inferodistal portion of the second article, while 5 had only a sparse patch of short hair. Three specimens from New Guinea and the Solomons carried long hair in a yet-denser tuft, while all of the specimens from the Red Sea lacked the tuft. Unfortunately this characteristic was correlated neither with other variation nor with colour pattern. In most specimens the third article was about 4 times as long as broad, but in one specimen from New Guinea the article was almost 7 times as long as broad.

4. Large cheliped. The length-breadth ratio did not vary greatly, but in some specimens the dactylus was markedly truncate at the tip and the plunger was a continuation of the distal cutting edge (fig. 55e) while in others the dactylar tip was extended as a rounded tooth and the plunger, while low, was definitely demarked from the more distal margin. The number of spines on the merus varied, and while none of the Australian specimens carried a distal tooth on the inferointernal margin, it was present in one specimen from the Solomons.

5. Small cheliped. The small chela varied from 2.7 to 3.1 times as long as broad, and of the 3 females from Australia with their small chelae present, 2 were sub-balaeniceps. However, in some large females from the Red Sea the dactylus had the two rows of setae almost joining on the superodistal margin.

6. Second legs: In De Man's specimen the first 2 carpal articles had the ratio of 10:7; in the series before us it varies from 10:6 to almost 10:10.

7. Third leg: The merus varied from 4.0-5.0 times as long as broad. De Man stated that the dactylus was simple and a little broader in the middle than at the base. In some of these specimens the article was definitely broadened and spatulate, but in others it approached a trigonal condition. The patches of setae were more numerous on the wider type of dactyl.

8. Colour: No two specimens for which Dr Randall had supplied colour transparencies are of the same colour pattern. Most have a white ground colour with olive-green to reddish-brown mottling or transverse stripes, often with a broad dark band across the chelae; in one, definitely red chromatophores made a coarse irregular reticulum on the carapace, while the abdomen carried more green-brown colour. Some have a white "saddle" at the posterior end of the carapace. One of the Australian specimens had a light reddish-grey ground colour and thin longitudinal stripes of light red. Another set of specimens (one from the Great Barrier Reef, and one each from Tanzania and the Societies) had a light to bright blue ground colour with darker blue transverse stripes, sometimes turning more olive towards the midline. Unique among the specimens was the blue specimen from the Societies (Moorea) for it also had a conspicuous spot on the posterolateral portions of the carapace of irregular oval shape

drawn out anteriorly and reaching from the level of the third maxillipeds to that of the fourth legs. The anterior portions were intense blue, but the wide posterior portion was mostly bright red.

Karplus *et al.* (1974) have reported they could recognize four major colour patterns, and that these colour types were usually associated with different species, or groups of species, of gobies and with different types of burrows. They conclude: "The diversity of the activities in the 4 types of shrimps, the composition of their associations, their burrow structures, and their substrate preferences lead us to the conclusion that these 4 types of shrimps may represent 4 valid species."

We suggest that the answer to this complex lies not in museum work with dead specimens, but in careful field observations correlated with laboratory studies on living specimens, such as that of Karplus *et al.* (1974), and those currently being studied by Ms Robina Cummins of the University of Sydney for her doctoral research (personal communication, Cummins). Some of the obvious questions are: Will shrimps of one "species" or of one colour pattern accept one of another colour pattern as a mate? Will one species of goby, always found in the field with one "species", or colour pattern, of shrimp, accept shrimps of another "species" under laboratory conditions? If the species of goby is changed, will the colour of its shrimp commensal change? It is only through studies like these that the question may be solved.*

BIOLOGICAL NOTES: A series of papers have been written on the behaviour patterns of the fish and shrimp in the association (see for example, Harada, 1969, Karplus *et at.*, 1972, Luther, 1958a and b, and Magnus, 1967). The shrimp obviously makes the burrow, but may be blind and certainly depends upon the fish for warning of danger. Under ordinary conditions during the day the fish rests on the sand slightly beyond the entrance to the burrow while the shrimp, when not excavating the burrow, rests closer to, or in, the entrance, resting its antennae on the fish. In the retreat response, the goby dives into the burrow head first, but the shrimp darts backwards. Both feed on articles of food falling near the mouth of the burrow and in addition the shrimp "cleans" the fish for ectoparasites, using its second legs (all taken from Karplus *et at.*, 1972).

AUSTRALIAN DISTRIBUTION: Seven of the specimens were collected at One Tree Island in the Capricorn Group and the other was collected from Lizard Island in the northern Great Barrier Reef.

GENERAL DISTRIBUTION: This species has been reported several times from the Red Sea and we have seen specimens from the head of the Red Sea eastward across the Indo-Pacific to the Society Islands (see above). It does not occur in Hawaii.

EDWARDSII GROUP

Orbital teeth lacking except in *A. euchirus* Dana (see p.197); in *A. hoplites* Nobili the

*N. V. C. Polunin and R. Lubbock, 1977, in "Prawn-associated gobies (Teleostei: Gobiidae) from the Seychelles, Western Indian Ocean: systematics and ecology" (J. Zool. Lond., 183:63-101) reported that they could separate 7 "types" of shrimp, based upon colour pattern in association with 11 species of gobies. The "types" of shrimp were not positively identified, but some may have been *A. rapax, A. bellulus, A. djiboutensis* and *A. rapacida.* They found in their narrow study area that some species of gobies were found in association with as many as 4 "types" of shrimps, and some "types" of shrimp associated with as many as 5 species of gobies. There was only one goby-shrimp association that was collected in sufficient numbers to show a species specificity on both sides of the relationship; that was the goby *Vanderhorstia ornatissima* Smith that was found always in association with the shrimp species "that may have been *Alpheus rapax*", and this alpheid was only found with *V. ornatissima* (Table V). This species association was the most common association found on sea grass beds (Table III), but it was a "particularly loose association" for the fish was "frequently found out of its burrow, and very occasionally individuals were found to shelter in the cylindrical shafts . . . thought to be made by callianassid prawns . . ." (p. 99). (Note added in press).

hoods themselves are acute, but without separate teeth (neither species has been reported from Australia). Large chela with marked compression, with a transverse groove on superior margin proximal to dactylus and, in all Australian species, a shoulder of various development opposite on inferior margin; groove on superior margin usually extending into both faces as triangular or quadrangular areas. Small chela of male often balaeniceps. Third legs with merus usually unarmed, dactylus usually simple, at times subspatulate.

Most species in this group are found in burrows in sandy to silty bottoms, often constructed under rocks lying on the substrate; they frequently penetrate into brackish water or occur where brackish water is leaked from beaches at low tide. They may be of large size and some species are collected by commercial shrimp trawls. A few species, most notably *A. parvirostris, A. hippothoe,* and *A. dolerus,* live in heads of dead coral on reefs well removed from terrestrial influences.

Alpheus parvirostris Dana
Fig. 56

Alpheus parvirostris Dana, 1852:551, pl. 35, fig. 3. Ortmann, 1890:483. De Man, 1911:432, fig. 106. Barnard, 1950:753, fig. 143 e-i. Banner and Banner, 1966b:149, fig. 57.

Alpheus lineifer Miers, 1875:343.

Alpheus braschi Boone, 1935:131, pl. 34, text fig. 10.

Previous Australian Records:
Coutière, 1900:413. Torres Straits,
McNeill, 1968:17. Low Isles.

SPECIMENS EXAMINED: 1 specimen from AC 15; 1 specimen, from AC 42, 43, 44, 45, 46, 48, 52, 53, 55, 59, 63, 66, 69, 71, 82; 2 AC C-59; 2, AH 1; 2, AH 4; 9, AM 52 (AM P. 27514); 3, AM 63 (AM P. 27794); 1, AM 80 (AM P. 27315); 1, AM 109 (AM P. 27511); 14, AM 123 (AM P. 28150); 1, AM 151 (AM P. 27827); 1, AM 163 (AM P. 27521); 1, AM 196 (AM P. 27316); 2, AM 201 (AM P. 27317); 9, AM 283 (AM P. 28151); 3, AM 305 (AM P. 28152); 2, AM 324 (AM P. 27345); 2, AM 331 (AM P. 27346); 1, AM 339 (AM P. 27347); 2, AM 340 (AM P. 27348); 2, AM 342 (AM P. 28153); 12, AM 343 (AM P. 27349); 3, AM P. 2579; 1, AM P. 7520; 1, AM P. 8043; 1, AM P. 10364; 1, AM P. 27433; 19, BAU 10; 8, BAU 11; 8, BAU 13; 1, BAU 15; 1, BAU 16; 1, BAU 17; 44, BAU 20; 4, BAU 21; 19, BAU 23; 9, BAU 24; 7, BAU 25; 19, BAU 27; 3, BAU 28; 17, BAU 29; 5, BAU 30; 3, BAU 31; 1, BAU 32; 2, BAU 37; 1, BAU 38; 5, BAU 39; 5, BAU 40; 2, BAU 41; 4, BAU 42; 16, BAU 43; 18, BAU 44; 2, BAU 47; 5, BAU 48; 2, BAU 49; 49, BAU 50; 14, BAU 52; 7, BAU 53; 21, BAU 54; 27, BAU 55; 32, BAU 56; 1, BAU 57; 6, BAU 58; 1, JC 18; 1, MM 263; 1, VM 29; 2, US 123564; 3, US 123578; 3, US 123584; 2, US 123585; 1, US 123586; 4, US 123588; 2, WM 70-65; 1, WM 281-65.

DIAGNOSIS: Rostrum narrow, over 2 times as long as broad at base, with tip reaching to near end of first antennular article, with short carina that disappears at base of eyes. Orbital hoods moderately inflated, orbitorostral groove shallow and flattened and extending forward to form flattened convex prominences between margins of orbital hoods and rostrum. Second antennular article 1.8 times as long as wide and a little longer than visible part of first and third article which are subequal. Stylocerite acute, reaching

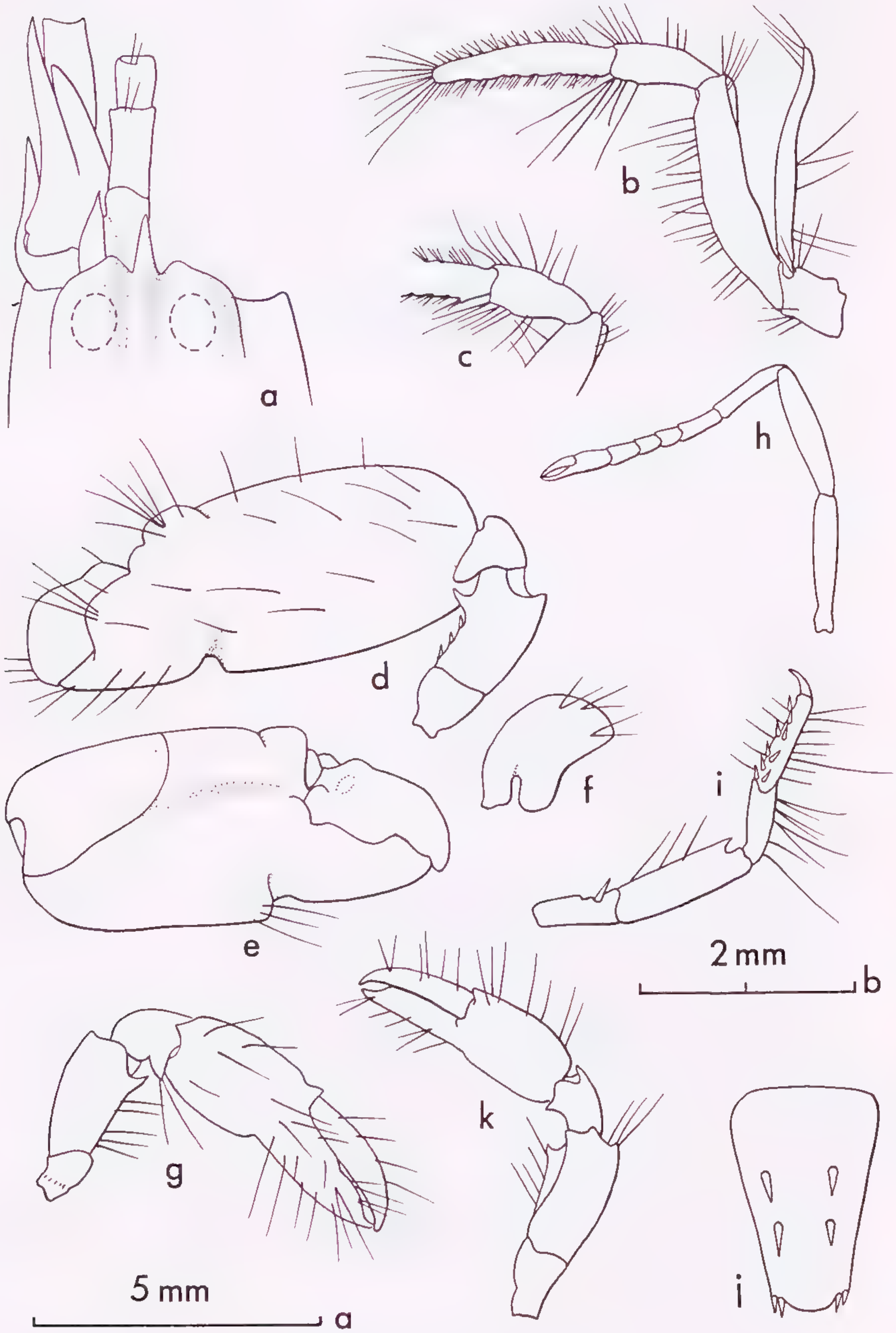

Fig. 56 *Alpheus parvirostris* Dana
12 mm male from BAU 20. **a.** Anterior region, dorsal view; **b, c.** third maxilliped, lateral face and detail of second article; **d.** large chelped, medial face; **e, f.** large chela and dactylus, lateral face; **g.** small cheliped, medial face; **h.** second leg; **i.** third leg; **j.** telson. 17 mm female from BAU 20. **k.** Small cheliped, lateral face. a, d, e, f, g, h, i, j, k scale a; b, c scale b.

slightly past end of first antennular article. Scaphocerite with outer margin markedly concave, lateral tooth strong and longer than antennular peduncle, equal to carpocerite; squamous portion narrow, reaching to end of antennular peduncle. Lateral spine of basicerite conspicuous in dorsal and lateral views, acute, reaching past first antennular article.

Ratio of the articles of third maxilliped: 10:4:8.

Large chela somewhat hirsute on medial face, 2.5 times as long as broad, fingers occupying distal 0.3. Superior saddle in form of a strong but narrow oblique groove that continues into medial face in a short U-shaped groove; other superior medial palmar depressions lacking. Superior saddle continuing into lateral face as small and abruptly terminating groove. Lateral face of chela bearing longitudinally a narrow and often deep groove arising at *linea impressa* and terminating below superior saddle; groove not confluent with groove of saddle. Inferior shoulder heavy but rounded and bearing a few long setae; inferior groove extending a short distance into both faces. Plunger on dactylus long. Merus of males stout, 1.7 times as long as broad bearing on inferointernal margin strong subterminal tooth and three small heavy spines. Merus of female more slender than that of male but with similar armature.

Small chela of male 3.0 time as as long as broad, fingers a little shorter than palm, conical; broad but acute tooth above dactylar articulation. Inferior shoulder present but not heavy. Inner face bearing many fine setae, outer face glabrous. Carpus cup-shaped, 0.3 as long as chela, bearing on its distosuperior margin a strong acute tooth. Merus similar to that of large chela but without spines. Small chela of female more slender with diminished sculpturing and less hirsute.

Ratio of the articles of the second legs: 10:7:3:3:4.

Ischium of third leg armed with heavy spine. Merus varying from 3.3-4.4 times as long as broad; inferior margin bearing several conspicuous bristles and usually a terminal tooth of varying development but at times absent. Merus of fourth leg usually with similar tooth. Carpus 0.5 as long as merus with both margins projected as acute teeth. Propodus 0.7 as long as merus, bearing on its inferior margin about 10 spines. Dactylus simple, 0.3 as long as propodus.

Telson 2.7 times as long as posterior margin is broad; anterior margin about twice breadth of posterior; posterior margin slightly arcuate.

DISCUSSION: *A. parvirostris* is one of the most common species of the genus *Alpheus* in the dead coral habitat throughout the Pacific. It does not vary much in proportions and is readily recognized by the unusually long lateral tooth of the basicerite coupled with the flattened prominences lateral to the rostrum. It does, however, vary in the teeth on the meri of the third and fourth legs, and we noted that the development of the teeth in a specimen is parallel in the two legs. We also noted that none of the specimens from Houtman Abrolhos carried these teeth which may indicate a subspecific type of isolation.

We have been able to examine the type for *A. braschi* Boone at the Vanderbilt Marine Museum. The sole apparent difference between this nominal species and *A. parvirostris* was the long groove on the median face of the large chela. On inspection this was found to be an artifact from preservation as the exoskeleton was newly moulted and soft. Since this species agrees in every other way with *A. parvirostris* we are placing it in synonymy. Coutière examined the type for *A. lineifer* and placed it in synonymy (1899:25).

BIOLOGICAL NOTES: This species has been dredged from 32 metres and is abundant on the reef flats. In addition to dead coral, it is found living in sponges.

Dr A. J. Bruce of the Heron Island Marine Station also loaned us a pair he found living on a head of the coral *Galaxea sp.* In our experience this is a unique habitat for this species, for while we have collected literally hundreds of *Racilius compressus* Paulson from *Galaxea* and even more *A. parvirostris* from many other habitats, we have never observed this species on living *Galaxea*. *A. parvirostris* is not a large species, we have not seen any specimens larger than 17 mm. The following colour notes were supplied by J. C. Yaldwyn from some specimens he collected at One Tree Island in the Capricorn Group. "Body transparent with green hands, broad dark green bands across the abdomen, eggs bright green, tips of fingers of big hand opaque, white." In the specimens collected by Davis and Bannon from Houtman Abrolhos the transverse bands were described as "dark brown". Colour notes on the specimen from AC 15 are as follows ". . . brown bands on back, claw has dark brown band, then yellow at end of claw. Dark region near head (eye). Light grey green colour for rest of body". This does not differ essentially from Yaldwyn's colour notes, the difference in banding colour is a common variation in alpheids.

AUSTRALIAN DISTRIBUTION: The species is represented in the collections from Houtman Abrolhos to Cockatoo Island in western Australia; in northern Australia from Darwin and the Torres Straits and in eastern Australia from Cooktown to the Capricorn Group.

GENERAL DISTRIBUTION: This species has been found from the Red Sea and South Africa, in the Indian Ocean and eastward across to Pacific to the Society Islands. It has been found in Japan, but not in Hawaii.

Alpheus edamensis De Man
Fig. 57

Alpheus hippothoe edamensis De Man, 1888a:518.

Alpheus edamensis De Man, 1911:437, fig. 107. Banner and Banner, 1966b:157, fig. 61.

Alpheus acanthomerus Ortmann, 1890:474, pl. 36, fig. 12. Coutière, 1897e:202.

Nec Alpheus Hippothoe edamensis De Man, 1897:757; 1902:891 (=*A. funafutensis* Borradaile).

SPECIMENS EXAMINED: 1 specimen from AM 302 (AM P. 28120); 1, AM 315 (AM P. 28121); 1, AM P. 8787; 1, AM P. 11400; 1, AM P. 28122; 2, AM P. 28123; 4, AM P. 28125; 2, BAU 29; 2, JC 7; 2, MC 1.

DIAGNOSIS: Rostrum slender, awl-shaped, reaching to end of first antennular article; carina high but rounded, depressed between orbits. Orbital hoods inflated, forming moderately deep orbitorostral grooves; anterior margins rounded, slightly concave near rostrum. Second antennular article 3 times as long as wide and 2 times as long as visible part of first and third article which are subequal. Stylocerite acute and reaching slightly past end of first antennular article, outer margin of scaphocerite concave; squamous portion narrow, reaching to end of antennular peduncle; lateral tooth reaching beyond carpocerite. Carpocerite 4.5 times as long as broad, reaching past end of antennular peduncle. Basicerite with acute lateral tooth.

Large chela 2.2 times as long as broad, with fingers occupying the distal 0.25. Plunger of dactylus long and heavy. Superior saddle U-shaped, proximal shoulder gradually rounded. Lateral palmar depression well defined, quadrangular, extending from saddle

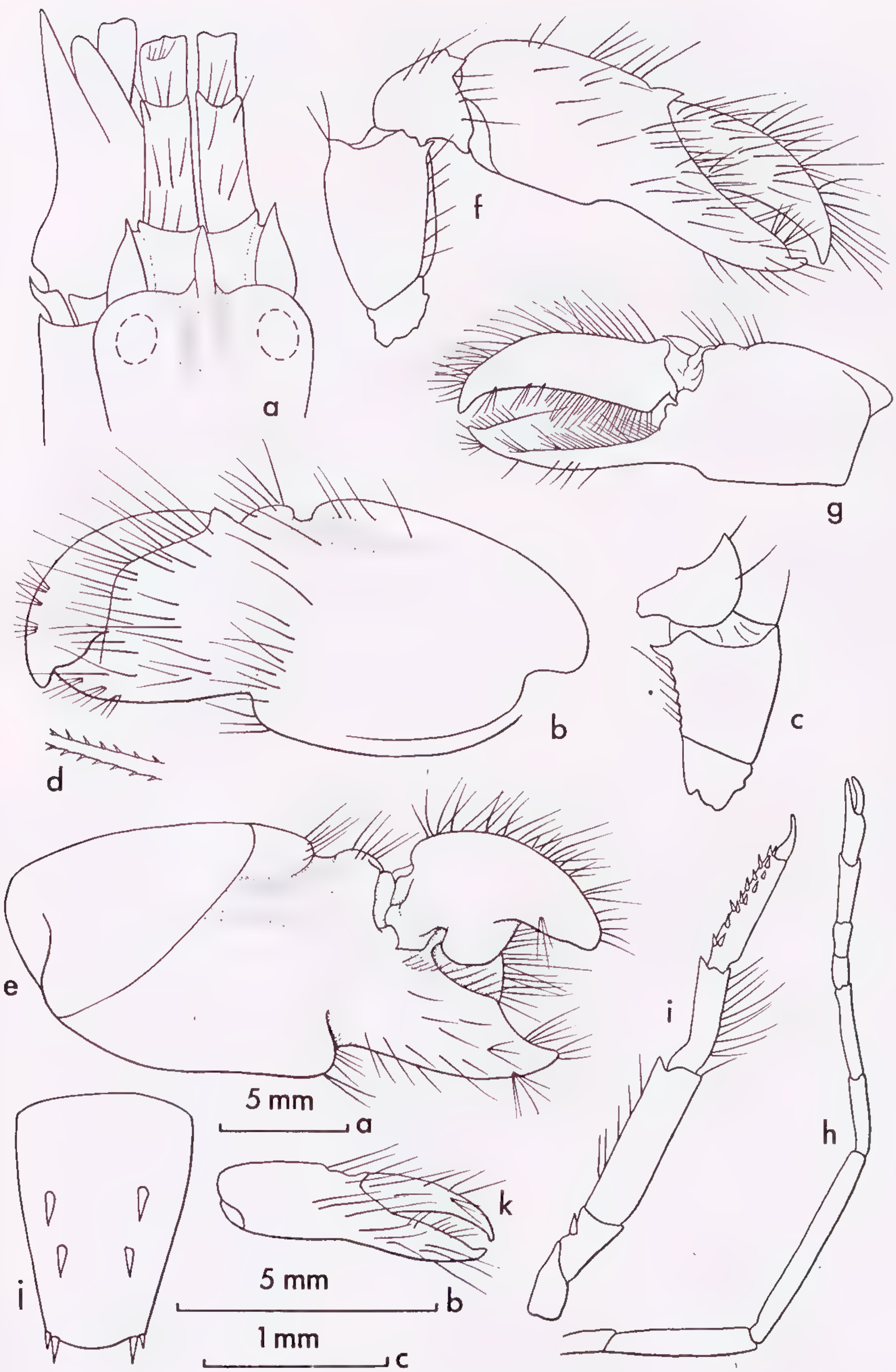

Fig. 57 *Alpheus edamensis* De Man
42 mm male from AM P. 14960. **a.** Anterior region, dorsal view; **b, c.** large chela and merus, medial face; **d.** detail of bristles of large chela; **e.** large chela, lateral face; **f.** small cheliped, medial face; **g.** small chela, lateral face; **h.** second leg; **i.** third leg; **j.** telson. 40 mm female from AM P. 14960. **k.** Small chela of female, medial face. b, c, e, f, g, h, i, k scale a; a, j scale b; d scale c.

groove proximally to *linea impressa*. Medial palmar depression extending proximally as a rough ill-defined triangle with apex near middle of palm. Inferior shoulder heavy, rounded and slightly projected. Inferior notch continuing into both lateral and medial face as poorly defined grooves. Medial face of chela hirsute in distal half. Merus nearly as broad as long with setae on its inferointernal margin and a strong distal tooth; other distal margins not projecting.

Small chela of male 3.0 times as long as broad with fingers slightly longer than palm. Dactylus broadened but without balaeniceps rows of hairs. Palm bearing trace of superior saddle and inferior shoulder and bearing strong tooth medial to dactylar articulation. Medial face of chela hirsute, hairs more abundant near fingers and directed forward. Lateral face of palm glabrous, lateral margin of pollex bearing patches of short stiff setae that cross with long, forward directed hairs on opposing margin of dactylus. Female chela more slender, 4.0 times as long as broad. Medial face less hirsute than in males; lateral face almost glabrous except near fingers. Merus of male similar to that of large chela, 1.5 times as long as broad and bearing on inferointernal margin short stiff setae and distally a strong tooth. Merus of female more slender, 2.0 times as long as broad.

Second legs with ratio: 10:12:3:3:7. Chela almost as long as last two articles.

Ischium of third leg with spine. Merus 4 times as long as broad with inferior margin projecting as an acute tooth distally and bearing several short fine setae. Carpus 0.6 as long as broad, both distal margins projecting as acute teeth. Propodus 0.7 as long as merus, bearing on inferior margin 14 short heavy spines with a pair distally. Dactylus simple, curved, 0.3 as long as propodus. Inferointernal margin of merus of fourth leg also armed distally.

Telson 2.4 times as long as posterior margin is broad. Dorsal spines with both posterior and anterior pair placed equal distance from middle.

DISCUSSION: Some confusion may arise with the differentiation of De Man in his key (1911:331) between this species and *A. funafutensis* Borradaile. The first two characteristics — the proportions of the merus of the third legs and the armature of the merus of the chelipeds — are valid, but for the third characteristic he states that the dactylus of the small chela of the male bears "a hairy crest on the inner side" in *A. edamensis* which is lacking in *A. funafutensis.* (Incidentally, *A. funafutensis,* which is known from the Malayo-Thai peninsula to the archipelagoes of the central Pacific, is not represented in the Australian collections). We interpreted this crest to be possibly like the crest observed in some of the species which have a sub-balaeniceps development; but we could not find it in any of the Australian specimens. De Man, who had no male specimens in his type material, has based his description on four specimens reported upon by Zehntner and also collected from Amboina. We were able to examine these same four specimens which were deposited in the Muséum d'Histoire Naturelle Ville de Genève through the courtesy of Dr Bernd Hauser, Curator of Arthropoda. We found that these males, too, lacked any marked setiferous crest; what De Man had interpreted as a crest was the rounded edge of the inner margin of the dactylus that had slightly more setae than elsewhere on the distal portions of the medial face of the chela. The small chela of Zehntner's specimen were exactly the same as the Australian specimens except that the larger males from Australia had more setae on the medial face than did Zehntner's smaller specimens. The separation between the two species otherwise is valid.

BIOLOGICAL NOTES: This species has been collected intertidally as well as dredged from 50 m. It is a large species, the largest in our collections being 48 mm.

AUSTRALIAN DISTRIBUTION: These specimens were all collected on the coast of Queensland from Princess Charlotte Bay to the Capricorn Group.

GENERAL DISTRIBUTION: Malaya; Thailand; Indonesia; Fiji; Samoa; Society Is.

Alpheus hutchingsae sp. nov.
Fig. 58

HOLOTYPE: 11 mm female from Lizard Island, Qld. 75 LIZ-3 (AM P. 27252).

ALLOTYPE: 11 mm male from same collection as type (specimen mutilated). (AM P. 27253).

DIAGNOSIS: Rostrum triangular, a little longer than broad at base, reaching to near end of first antennular article; bearing rounded carina that extends just past base of eyes. Orbital margins regularly rounded and confluent with rostrum, not indented at base of rostrum. Orbital hoods moderately inflated forming moderately deep but rounded grooves between carina and orbital hoods. Visible part of first and third antennular articles equal, second article 2 times as long as first and 1.8 times as long as broad. Stylocerite acute, reaching end of first antennular article. Outer margin of scaphocerite concave, squamous portion reaching to last quarter of third antennular article, lateral tooth strong, reaching well past antennules; carpocerite reaching slightly past end of antennules. Basicerite bearing small but acute tooth.

Ratio of articles of third maxilliped: 10:2.5:6, tip blunt and with only sparse setae.

Large chela 2.5 times as long as wide, fingers occupying distal 0.3. Dactylus truncate, plunger low and confluent with margin of dactylus. Superior saddle narrow and shallow; proximal shoulder rounded, not overhanging; distal shoulder gradually rounded. Saddle continuing medially into small, poorly defined triangular depression, not reaching middle of palm and extending laterally into poorly defined quadrangular depression reaching slightly past mid-palm. Inferior shoulder low, rounded and followed distally on lateral face by small triangular depression. Medial face of chela lightly hirsute. Merus 2.8 times as long as broad, bearng a small acute tooth distally on inferointernal margin, superior margin terminating in rounded projection bearing a few setae.

Carpal articles of second leg with ratio: 10:5:2.5:2.5:4.

Ischium of third leg with spine. Merus 3.8 times as long as broad, bearing distally a small acute tooth, margins bearing scattered setae. Carpus 0.6 as long as merus, distal margins projected into rounded teeth. Propodus 0.7 as long as merus, bearing on its internal margin 6 spines and a pair distally; distal pair nearly as long as dactylus. Dactylus 0.3 as long as propdous, simple.

Telson 2.8 times as long as posterior margin is broad, and 2.2 times as broad anteriorly as posteriorly. Anterior pair of dorsal spines placed just anterior to middle.

DISCUSSION: We have two 11 mm specimens, one male and one female from Lizard Island. Of the two specimens the female is better preserved so we have designated it as the holotype. Both specimens lack the small chela and the male also lacks the large chela.

These specimens belong to that group of species in the Edwardsii Group that have a tooth on the merus of the third leg, a simple dactylus, and have the second carpal article of the second leg about half the length of the first; these include *A. hippothoe* De Man, *A.*

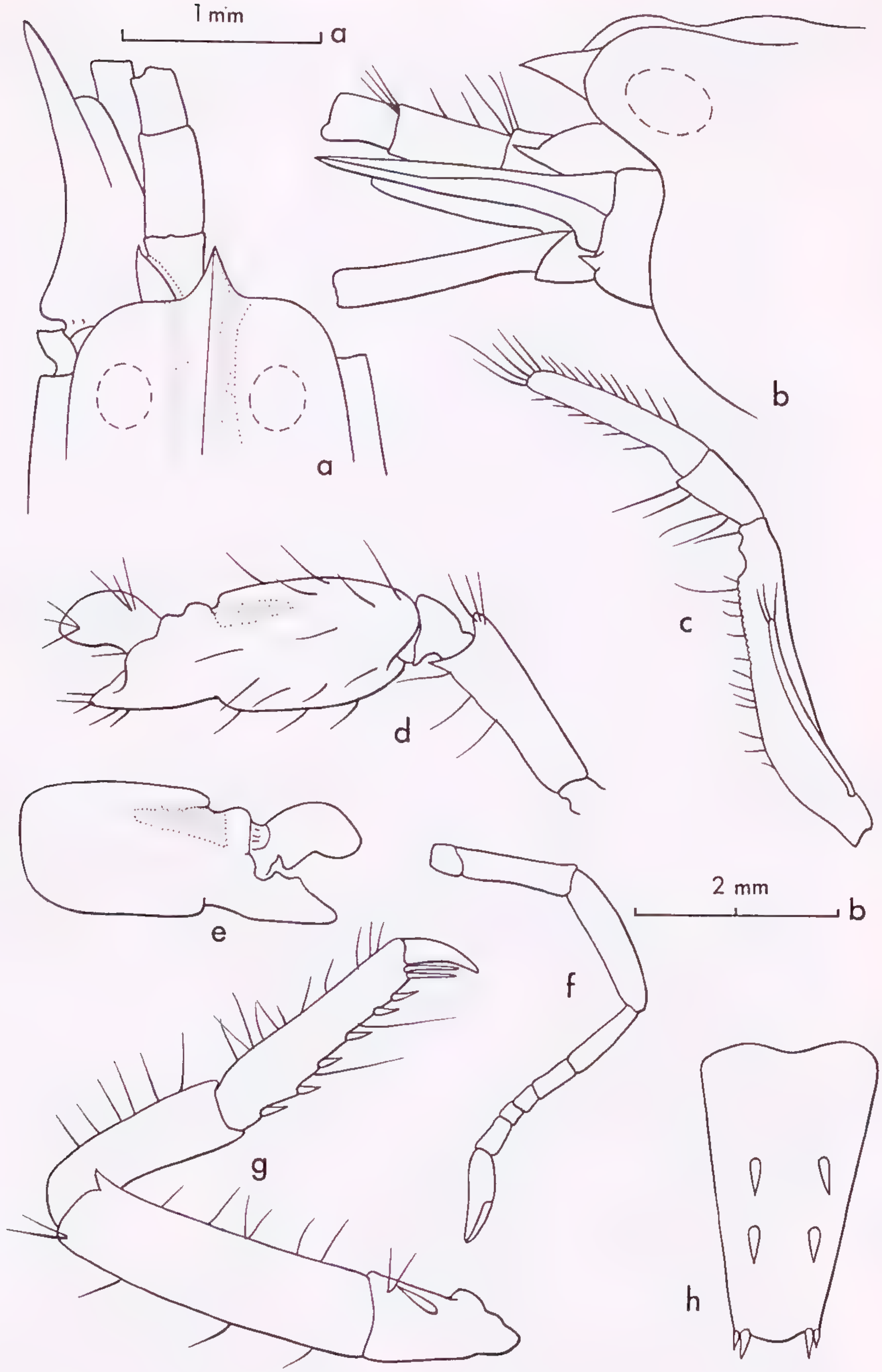

Fig. 58 *Alpheus hutchingsae* sp. nov.
Holotype (female). **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d.** large cheliped, medial face; **e.** large chela, lateral face; **f.** second leg; **g.** third leg; **h.** telson. a, b, c, f, g, h scale a; d, e scale b.

serenei Tiwari, *A. georgei* B&B and *A. euchiroides* Nobili. The group does not include *A. euchirus* Dana which lacks the tooth on the merus of the third leg (see discussion under *A. serenei,* p. 197). From all it differs in the confluence, without an identation, of the orbital margins with the rostral margin, and in the small number of spines on the propodus of the third legs (even *A. euchiroides* has six pairs, rather than six spines).

The sculpturing of the large chela is markedly less than in all except *A. euchiroides,* but that species, to judge from Nobili's figure (1907:pl. 1, fig. 6b), has even less sculpturing than this species. We do not know if this species has a tendency to develop a notch on the dactylus of the third leg as does *A. serenei* and possibly *A. georgei*. There are other differences, some of which may be found to be significant when a greater series of specimens are studied, in the proportions of the antennular peduncle, the large chela and the third legs. It is unfortunate that the small chela of the male is not available as this often shows significant characteristics in the Edwardsii Group.

The species is named after Dr Patricia Hutchings of the Australian Museum who collected this and other interesting specimens for us at Lizard Island (see, for example, *Prionalpheus*). The holotype and paratype will be placed in the Australian Museum, Sydney.

BIOLOGICAL NOTES: These specimens were collected in 35 ft of water, from a solid reef rock habitat and were found among the encrusting sponges and algae.

Alpheus hippothoe De Man
Fig. 59

Alpheus hippothoe De Man, 1888b:268, pl. 17, fig. 1-5. Coutière, 1898i:197.

Nec Alpheus hippothoe Banner and Banner, 1966b:151, fig. 58 (= *A. serenei* Tiwari).

SPECIMENS EXAMINED: 2 specimens from AM 160 (AM P. 27800); 2, WM 26-65; 1, WM 79-65; 1, WM 156-65; 2, WM 172-65; 1, WM 217-65; 2, WM 233-65; 1, WM 279-65.

DIAGNOSIS: Rostrum slender, 2.5 times longer than broad, reaching to end of first antennular article; bearing rounded carina that extends to end of gastric region. Carina depressed between the moderately inflated orbits and rising abruptly just anterior to base of eyes so that in profile the carapace appears humped. Visible part of first and third antennular articles equal, second article more than twice as long as third and 2.7 times as long as broad. Stylocerite acute, reaching near end of first antennular article. Squamous portion of scaphocerite reduced and narrow, reaching near middle of third antennular article; lateral margin markedly concave, lateral tooth reaching well past antennular article. Carpocerite reaching slightly past end of lateral tooth of scaphocerite, four times as long as broad. Basicerite bearing narrow acute lateral tooth.

Second and third articles of third maxilliped bearing numerous slender setae on superior margin, distal end of third article with dense brush of long setae.

Large chela 2.3 times as long as wide, fingers occupying the distal 0.3. Dactylus truncate distally, plunger low and truncate. Proximal shoulder on superior margin rounded but strongly overhanging saddle; saddle deep, narrow, distal shoulder gradually rounded. Lateral palmar depression quadrangular, well defined, reaching to *linea impressa*. Medial palmar depression triangular, well defined, reaching proximally to middle of palm. Inferior shoulder heavy, rounded, at right angles to palm. Inferior notch continuing onto lateral face as a small but ill-defined triangular depression. Pollex bearing a longitudinal depression on lateral face placed well above the inferior margin and expanding proximally into a roughly triangular depression disappearing near middle

of chela; depression not confluent with inferior notch. Inferior notch continues onto the medial face as a slight diffuse triangular groove that extends somewhat proximally into palm. Medial face lightly hirsute. Merus 1.3 times as long as broad, superodistal margin slightly projected, rounded; inferodistal margin bearing a few fine setae and acute tooth distally.

Small chela stout, 2.7 times as long as broad, fingers a little shorter than palm. Palm without sculpturing except for a small rounded ridge on superior margin terminating in a subacute tooth on medial side of dactylar articulation. In small male specimens this shoulder is lacking. Opposing surfaces of fingers excavate. Medial face of chela moderately hirsute, more dense distally than proximally, lateral face nearly glabrous. Merus similar to that for large chela, but with inferodistal tooth reduced.

Carpal articles of second leg with a ratio: 10:5:2:2:4. Chela as long as last three articles.

Ischium of third leg bearing strong spine. Merus 3 times as long as broad, bearing strong acute tooth subterminally on inferior margin. Carpus 0.5 as long as merus, inferior and superior margins projected distally. Propodus 0.7 as long as merus, bearing on its inferior margin about 7 pairs of spines. Dactylus simple, 0.3 as long as propodus.

Telson 2.8 times as long as posterior margin is broad. Distal and proximal spines on dorsal surface located equidistance from midline. Distolateral margin on inner uropod bearing several heavy spines.

DISCUSSION: Evidently of the three specimens from the Mergui Archipelago that De Man based his description upon none was selected as the holotype, and the male and female from Sullivan Island were deposited in the Indian Museum in Calcutta and the lone male from King Island Bay in the British Museum (Natural History) in London. We have examined these three specimens as well as the two specimens collected by the Siboga Expedition from "Sulu-island" (=Jolo Is) that he identified as this species in the Zoologisch Museum in Amsterdam. Our specimens agree well with his specimens from Sulu, but we found the Australian specimens and the Sulu specimens differ slightly from those from Mergui. As De Man noted (1911:434) the meri of both chelipeds bear acute teeth in the Siboga specimens that are merely angular in the syntypes. On the small chela of the male in the Indian Museum there is a slight but definite transverse groove behind the dactylus that continues slightly into the lateral face of the palm, which is lacking on the female syntype while in the Australian males and females it is a slight notch leading to a flattened area behind the dactylar articulation. We regard these slight differences as unimportant, as did De Man with his Siboga specimens. We should note that De Man in his description overlooked the presence of a spine on the basicerite and we are including the drawing of the syntype at the British Museum (Natural History) to illustrate the characteristic.

This species is most closely related to *A. euchirus* Dana and *A. serenei* Tiwari. From both it differs in that the medial side of the dactylus of the small chela of the male bears many long setae, but none in a distinct crest while the other two species have a definite setiferous crest. In addition, in *A. hippothoe* the merus of the third leg is 3 times as long as broad and in *A. euchirus* it is over 4 times. In *A. hippothoe* the small chela is 2.6-2.8 times as long as broad, and the dactylus of the third leg is simple, whereas in *A. serenei* the small chela is more slender, 3.0-3.8 times as long as broad and the third legs have a secondary unguis on the dactylus.

BIOLOGICAL NOTES: This species is found most commonly in interstices of dead coral collected intertidally or in dredge hauls made in fairly shallow water. However, the

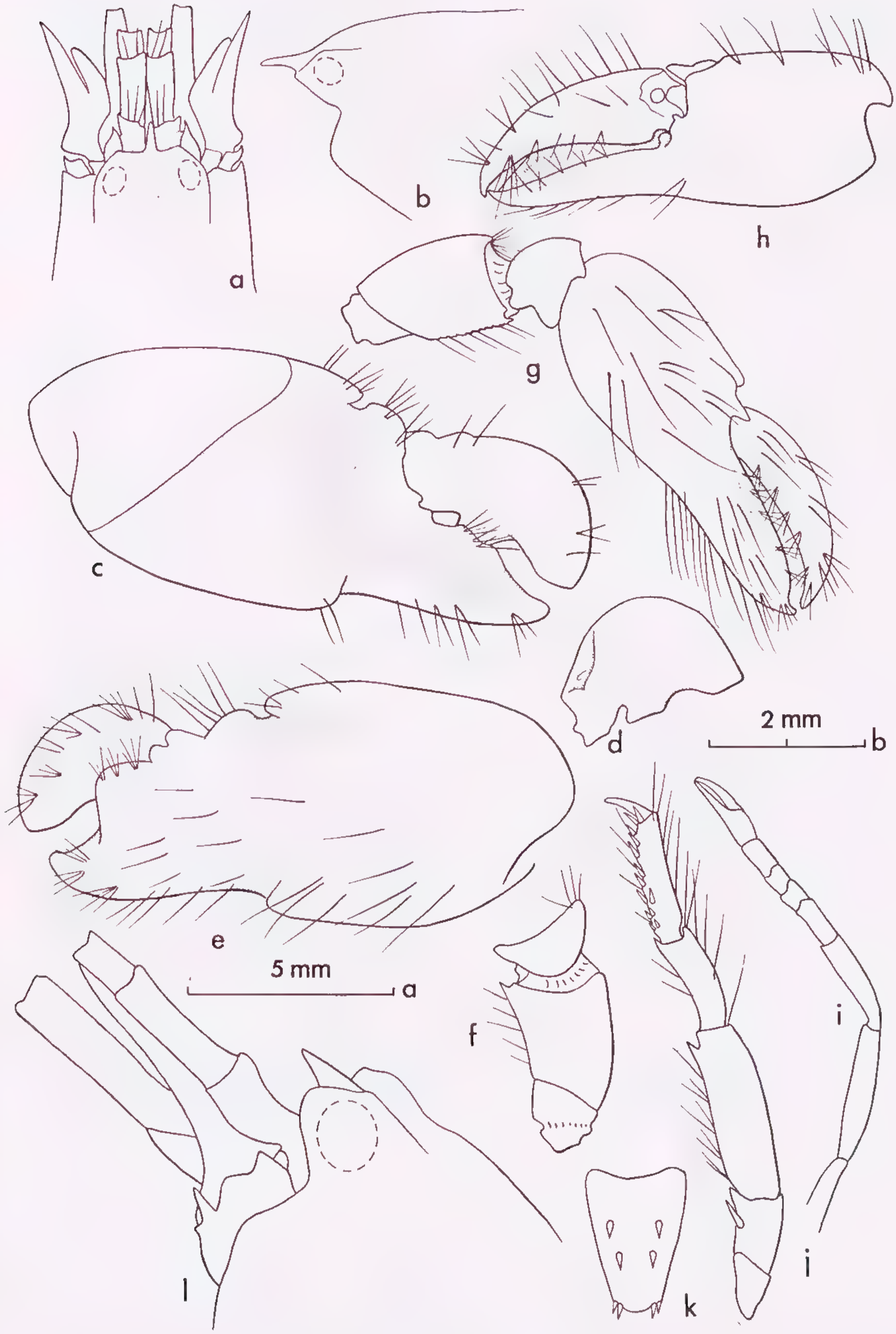

Fig. 59 *Alpheus hippothoe* De Man
28 mm male from WM 172-65. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and dactylus, lateral view; **e, f.** large chela and merus, medial view; **g.** small cheliped, medial view; **h.** small chela, lateral view; **i.** second leg; **j.** third leg; **k.** telson. Syntypic specimen, a 28 mm male, from the Mergui Archipelago. **l.** Anterior region, lateral view. a, b, c, d, e, f, g, h, i, j, k scale a; l scale b.

specimen from Bedout Island (WM 79-65) was collected at 25 fathoms. Coutière (1898i:197) reports on the colour for some specimens from Djibouti ". . . *marqué de bandes transversales vert olive, nuancées de brun clair, et la rame externe des uropodes porte . . . une tache bleue oculiforme sur son tiers distal.*" Our specimens range up to 30 mm in length.

AUSTRALIAN DISTRIBUTION: All except 2 of our specimens were collected from northwest Australia, the remaining two were collected near Darwin.

GENERAL DISTRIBUTION: Red Sea; South Africa; Indian Ocean; Malaysia; Indonesia; Philippines; Fiji; Tonga.

Alpheus serenei Tiwari
Fig. 60

Alpheus serenei Tiwari, 1963:310, figs. 27, 28; 1964:314.
Alpheus hippothoe De Man *var.?* De Man, 1897:754, figs. 66-66c.
Alpheus euchirus Coutière, 1899 *(passim)*. De Man, 1911:434; 1922:42, pl. 4, figs. 18, 18b *(partim)*. Calman, 1939:209. Johnson, 1962a:54. (*Nec* Dana, 1852.)
Alpheus hippothoe Banner and Banner, 1966b:151, fig. 58. *(Nec* De Man, 1888b.)

SPECIMENS EXAMINED: 2 specimens from AM 200 (AM P. 28126); 2, BAU 27; 2, WM 233-65.

DIAGNOSIS: Rostrum reaching variously from middle to end of first antennular article. Rostral carina strong, depressed between anterior orbital hoods, rapidly rising near their posterior margins to form slight hump and continuing to middle of carapace. Orbitorostral grooves moderately shallow. Frontal borders of orbital hoods extended as slight arcuate prominences almost giving appearance of orbital teeth in lateral view. Second antennular article 2.5 times as long as broad, 1.7 times as long as first and 2.1 times as long as third. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with squamous portion narrow, reaching to end of antennular peduncle; lateral tooth reaching well past end and equal in length to carpocerite. Inferior margin of basicerite with strong tooth.

Large cheliped 2.2 times as long as broad, with fingers occupying distal 0.35. Superior saddle deep, proximal shoulder overhanging groove, distal shoulder gradually rounded. Lateral depression quadrangular, extending to *linea impressa,* medial depression triangular with apex reaching proximally beyond middle of palm. Plunger of dactylus almost confluent with distal margin. Merus almost as broad distally as long, inferointernal margin projecting distally as strong tooth; superodistal angle slightly projecting but rounded.

Small chela of male 3.5 times as long as broad, palm without sculpture. Lengths of fingers and palm subequal, fingers slightly broadened proximally. Medial face of dactylus bearing an oblique crest of hairs that almost reaches superior surface. Medial face of chela moderately hirsute. Lateral face of dactylus with oblique ridge similar to medial face but much shorter and without hairs. Lateral face of chela nearly glabrous. Merus 2 times as long as broad, bearing small acute tooth distally on inferointernal margin. Small chela of female similar to male, but with oblique crest on medial face of dactylus lacking hairs.

Carpal article of second legs with a ratio: 10:5:2:2:4.

Ischium of third leg with heavy spine. Merus of third leg more than 4 times as long as broad, bearing large acute subapical tooth on inferior margin. Merus of fourth leg

bearing similar tooth but apically. Carpus 0.5 as long as merus; superodistal margin terminating in a rounded tooth, inferodistal margin terminating in a strong subacute tooth. Propodus 0.6 as long as merus, bearing on its superior margin long slender hairs and 8 pairs of spines on inferior margin. Dactylus 0.3 as long as propodus, usually bearing on its inferior surface a notch representing a secondary unguis, but notch at times lacking.

Telson 2 times as long as posterior margin is broad. Anterior pair of dorsal spines placed anterior to middle; distolateral margins of inner uropods bearing some small spines.

DISCUSSION: Our specimens vary only slightly from Tiwari's. The merus of the large cheliped and the telson are stouter, the first article of the second leg is shorter in relation to the second and the secondary unguis of the dactylus of the third leg appears almost obsolete in our specimens. However, these characters are variable and we do not attach any significance to the differences.

This species is very close to *A. euchirus* Dana and *A. hippothoe* De Man and has been confused with both species in the previous literature. The separation from *A. euchirus* is given below; possibly the best separation of it from *A. hippothoe* lies in the presence of the flattened area in front of the orbital hoods and the setiferous crest on the medial side of the dactylus of the small chela which are not found in *A. hippothoe;* the tendency to develop a notch on the inferior surface of the dactylus of the third leg has not been noted in *A. hippothoe* as well. Using these criteria, we now find that all of the 128 specimens we reported from Thailand are *A. serenei* although most of them lacked the trace of biunguiculation on the dactylus of the third legs.

This species is also similar in several ways to *A. georgei* and *A. hutchingsae,* both described as new in the adjacent sections; their separation will be discussed under each.

BIOLOGICAL NOTES: We reported that we found this species in Thailand in association with an ophiuroid which was identified by Dr Dennis Devaney of the Bishop Museum, Honolulu, Hawaii as *Macrophiothrix longipeda.* The ophiuroid was located in a deep recess at the base of a dead coral head and the shrimp was found at the mouth of the recess. Johnson *(loc. cit.)* found it was "a crevice dweller and thus limited to hard bottoms". This species has been collected in water as deep as 60 metres. Tiwari's specimens were taken from the "coral reef" in one metre of water and we have several specimens collected at about 3 metres in the southern Philippines. We have seen specimens up to 28 mm in length.

AUSTRALIAN DISTRIBUTION: Specimens came from Broome and Dampier Archipelago in Western Australia and from Torres Straits in northern Australia.

GENERAL DISTRIBUTION: Red Sea; Indonesia; Singapore; Gulf of Thailand; Vietnam; Philippines.

The identity of **A. euchirus** Dana, 1852

In 1852 (p. 545) Dana described a specimen (sex undesignated) as *A. euchirus* from the Balabac Straits, lying between northern Borneo and the Philippine island of Palawan. The depicted form of the large chela places this in the Edwardsii Group. In the description itself, in the key leading to the description of the species, and in the figures (which are very small, rendering it difficult to discern details), Dana specified certain characteristics that would separate this species from all of the others placed within the Edwardsii Group. As far as we can determine the holotype has been lost so Dana's description and figures

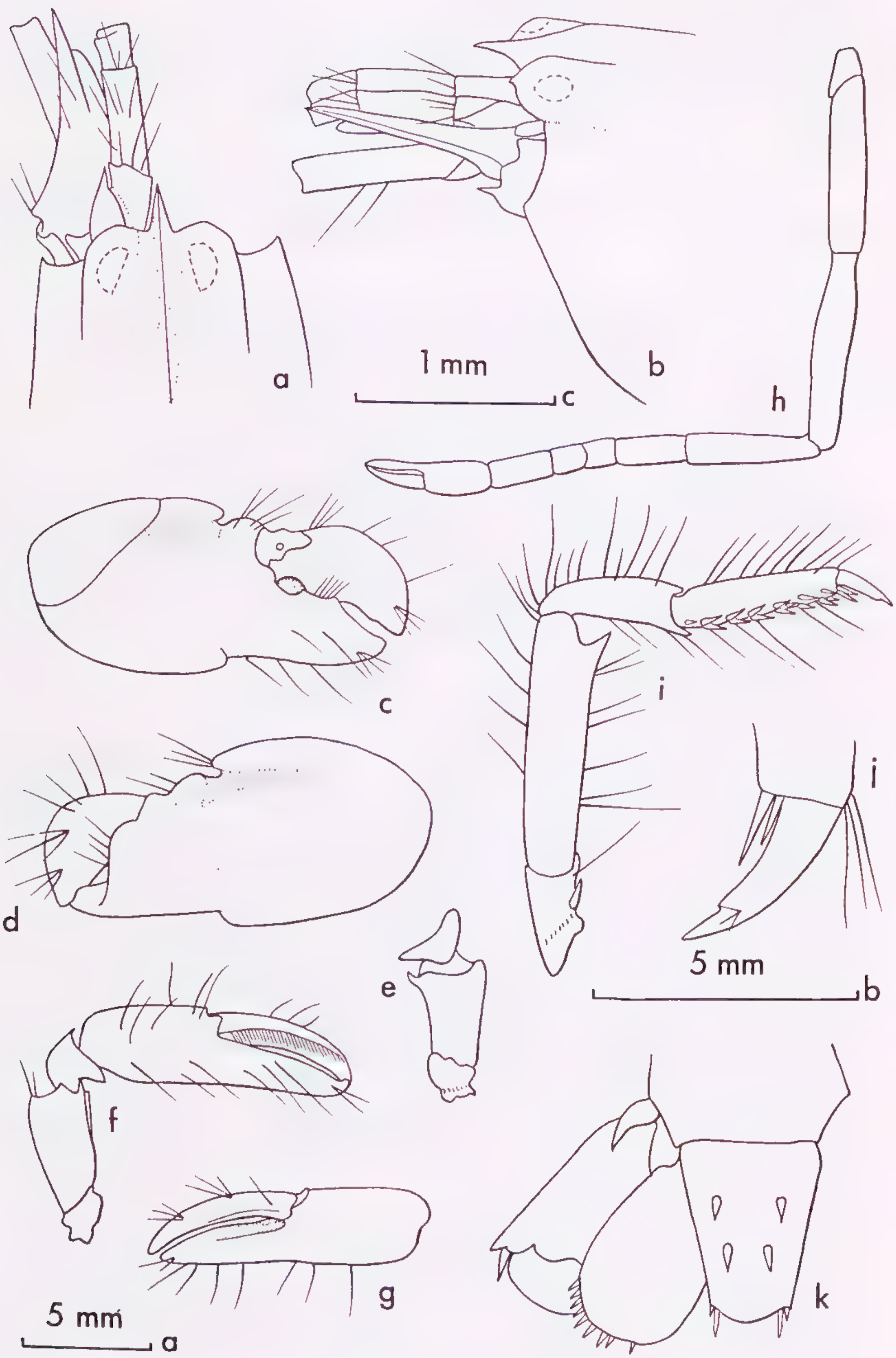

Fig. 60 *Alpheus serenei* Tiwari
30 mm male from BAU 27. **a, b.** Anterior region, dorsal and lateral view; **c.** large chela, lateral face; **d, e.** large chela and merus, medial face; **f.** small cheliped, medial face; **g.** small chela, lateral face; **h.** second leg; **i, j.** third leg and enlarged dactylus; **k.** telson and uropods. c, d, e, f, g scale a; a, b, h, i, k scale b; j scale c.

alone must be used to establish the characteristics of the species. Using these sources in Dana, we have assembled a description of the species as follows:

Rostrum acute, reaching to near end of first antennular article, continued posteriorly between eyes as a carina. Margins of orbital hoods armed with small teeth. Second antennular article a little longer than first. Scaphocerite not longer than carpocerite. Spine on basicerite absent or obsolescent (not shown at all in fig. 6a).

Third article of third maxilliped tapering to narrow tip; superior margin and tip carrying long setae, with those of tip about equal in length to article.

Large chela about twice as long as broad, with fingers about half as long and half as broad as palm. Superior saddle not well marked distally, with proximal shoulder apparently not overhanging floor of groove; inferior shoulder heavy but not acute; an apparent groove or rounded ridge reaching on outer face from *linea impressa* to superior saddle. Merus not spinose on apex. Small chela with fingers heavy, not balaeniceps (in specimen drawn), slightly longer than palm; palm about 1.2 times as long as broad. Both chelae with light pubescence on both faces, but with more hair on superior portions of inner faces.

Second legs a little longer than third, with first carpal article twice length of second and chela "hardly shorter than sum of three preceding".

Third and fourth legs "sparingly hairy". Merus of third legs about 4 times as long as broad, "very short acute at inner apex" (yet specified in dichotomy A of key as *"omnino inermis"* and shown in figure 6f as having the inferior margin meet the distal margin at approximately a right angle). Propodus "with seven or eight sets of spinules" on inferior margin.

Length "three-fourths of an inch" (19 mm).

The outstanding characteristics of the species would be these: First, and most important, would be the orbital teeth and we can see no other interpretation of Dana's key characteristic of "b. *Orbitae margo spinula armatus"* and his depiction of a short thin tooth in side view; this characteristic is unique within the Edwardsii Group. Other characteristics would include the reduced or absent tooth on the basicerite; the tapering third article of the third maxilliped; the lack of a tooth on the merus of the large cheliped; and the lack of a tooth on the merus of the third leg. All of these characteristics separate *A. euchirus* from *A. serenei, A. hutchingsae* B&B and *A. georgei* B&B.

The species has been reported a few times in the literature since its description. Coutière in 1899 reported a single specimen from Djibouti (p. 488) but he specified that the merus of the third leg carried a tooth (p. 260) which is contrary to Dana's characterization. De Man also applied Dana's name to some specimens in 1911 (p. 434) and 1922 (p. 42) (and retroactively, to specimens he had reported in 1897:754 and 1898c:210 as *A. hippothoe* var.?); he had Coutière's specimen for comparison and while all of the specimens were somewhat similar, he was doubtful if the group was identical with the species described by Dana. He thought that a rounded shelf extending in front of the margins of the orbital hoods might, in side view, be confused with an orbital tooth; he had misgivings about the presence of a tooth on the merus of the large chela, but he rather ignored the fact that in all the specimens the inferodistal angle of the third legs projected as an acute tooth. Through the courtesy of the Zoologisch Museum in Amsterdam we were able to examine the 10 specimens De Man reported in 1911 and the 4 specimens reported in 1922 and found all, save one, to have the characteristics of *A. serenei* and not those given by Dana. The one specimen, that from Sumatra, is *A. georgei*

that we are describing below. We were unable to locate either Coutière's specimen or the six that De Man had earlier reported as *A. hippothoe* var.? from Atjeh, but we presume that as De Man had examined them and found them similar to the 1911 specimens, they, too, were *A. serenei*.

The name *A. euchirus* was also used by Calman for a male and a female specimen from the Red Sea (1939:209). These, too, we were able to examine through the courtesy of the British Museum (Natural History). They differed from *A. serenei* of the western Pacific in only three characteristics; (1) the dactylus of the small chela of the male had a setiferous fringe on both faces; (2) the merus of the third leg carried only a small apical tooth and that of the fourth leg was inermous, while in the Pacific specimens the tooth on the third leg was larger and slightly subapical and the fourth leg had a small apical tooth; (3) the dactylus of the third legs in both specimens were devoid of any indication of biunguiculation (a characteristic we found in many of our Thai specimens). These characteristics may be found in the future to be adequate for a subspecific separation of the two forms.

The last person to use the name *A. euchirus* was Johnson (1962a:54) who found the form he discussed to be common in the waters about Singapore. Through the courtesy of Dr S. H. Chuang of the University of Singapore we were able to examine three of the specimens Johnson called *A. euchirus*. These specimens agree exactly with Tiwari's description of *A. serenei* and with the Australian and Thai specimens except all three lacked the biunguiculate dactylus on the third legs, but that is, as we have pointed out above, a variable characteristic.

We had the hope that in our extensive collections made in southern Mindanao and the Sulu Archipelago in the Philippines, only about 600 miles east of Balabac Straits, we would have one or more specimens that could be identified as *A. euchirus* without any question, but no such specimens were found. We conclude that if Dana's description of *A. euchirus* is correct, there is no way to expand upon it unless a very similar form is found in the type location and is used as a neotype. A similar situation has occurred in *A. pugnax* that Dana described from the island of Maui, Hawaiian Islands (1852:554). The species is clearly defined and can easily be separated from all related forms in the Hawaiian Islands, yet has never been reported since the original record in spite of the fact that we have made many trips to the type locality to search for it (Banner, 1953:116).

Alpheus georgei sp. nov.

Fig. 61

Alpheus euchirus De Man, 1922:42 *(partim)*, pl. 4, figs. 18, 18b. *(Nec* Dana, 1852. see p.303).

HOLOTYPE: 22 mm male from 40 mi. W. of Cape Jaubert. 23 fms. Collected by R. W. George on the Dorothea, 13/10/62, from sponge. (WM 226-65).

ALLOTYPE: "1 full-grown (37 mm) ova-bearing female collected 10 May by Mr Van Nouhuys west of Segli, north coast of Sumatra, at a depth of 72-126 m." (De Man, *loc. cit*).

DIAGNOSIS: Rostrum triangular, as long as broad at base, tip rounded, reaching to last quarter of visible part of first antennular article. Orbitorostral grooves shallow, disappearing just posterior to orbital hoods. Rostral carina rounded. Frontal border of orbital hoods extended as slight arcuate prominences giving appearance of small orbital teeth when seen in lateral view. Second antennular article 1.6 times as long as broad and visible part of first antennular article and third article equal in length, 0.6 as long as

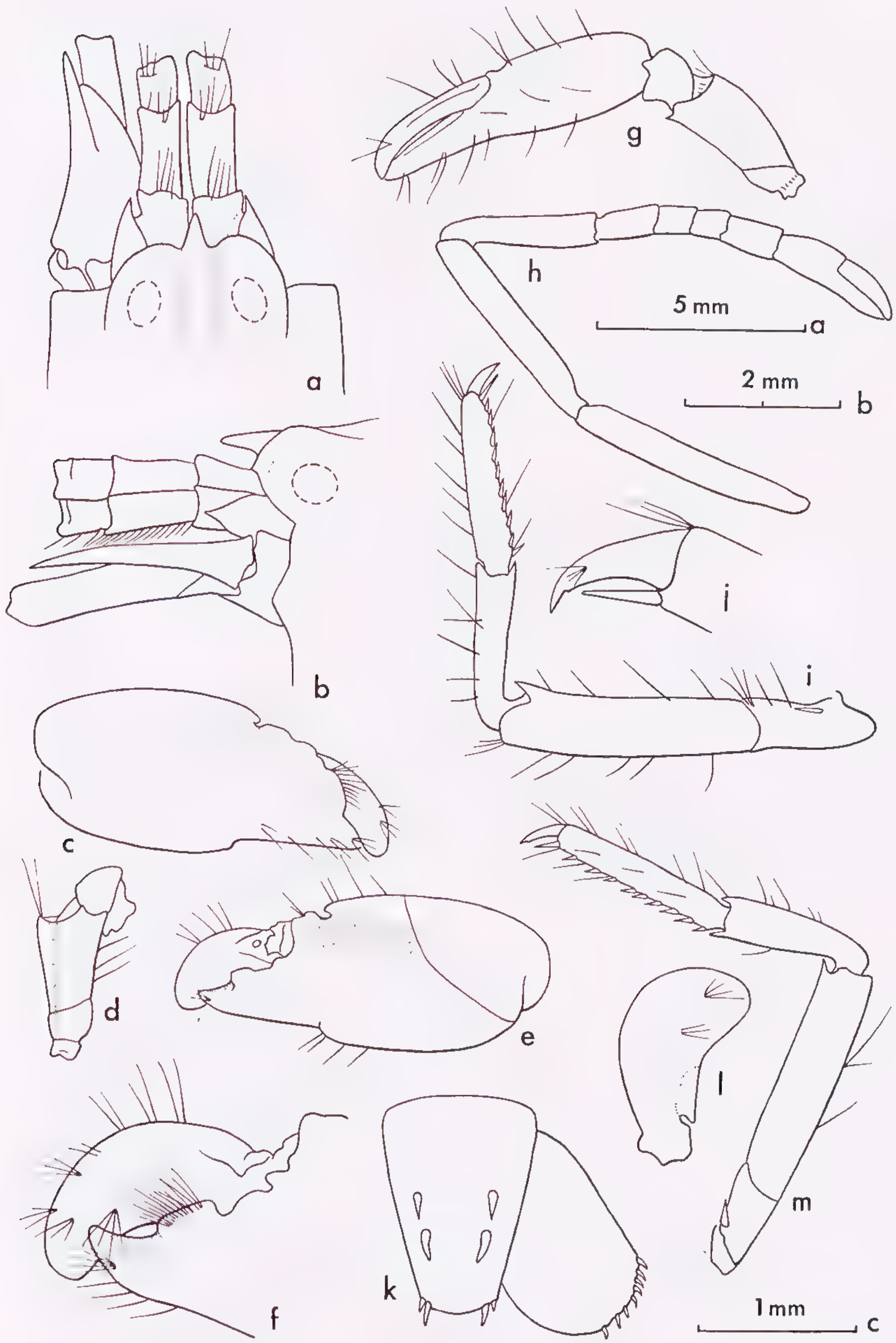

Fig. 61 *Alpheus georgei* sp. nov.
Holotype (22 mm male). **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and merus, medial face; **e, f.** large chela and enlarged distal portion, lateral face; **g.** small cheliped, medial face; **h.** second leg; **i, j.** third leg and enlarged dactylus; **k.** telson and uropods. Allotype, 37 mm female from Sumatra (= *A. euchirus* Dana of De Man, 1922 see text). **l.** Dactylus large chela; **m.** third leg. c, d, e, g, l, m scale a; a, b, f, h, i, k scale b; j scale c.

second. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with squamous portion narrow, reaching to end of antennular peduncle, lateral tooth reaching well past end of squame, nearly equal in length to carpocerite. Carpocerite reaching past the third antennular article by 0.7 its length. Inferior margin of basicerite with acute tooth.

Ratio of articles of third maxilliped: 10:3:6.6.

Large cheliped 2.4 times as long as broad with fingers occupying the distal 0.3; palm 2.0 times as wide as fingers. Superior saddle deep, proximal shoulder overhanging, distal shoulder gradually rounded. Lateral depression quadrangular, extending to *linea impressa,* medial depression triangular reaching to almost half length of palm. Inferior shoulder rounded, only moderately heavy, not extended. Dactylus moderately compressed, truncate at tip and markedly overhanging pollex. Distal margin of plunger almost confluent with cutting edge. Merus 1.7 times as long as broad, inferointernal margin bearing several long setae, terminating in a strong rounded tooth, superodistal and inferoexternal margins not projected distally.

Small chela of male 3.7 times as long as broad, fingers and palm almost equal. Palm without grooves, terminating in a small subacute tooth at dactylar articulation, medial face lightly hirsute, lateral face glabrous. Medial face of dactylus bearing a slight longitudinal crest in the proximal 0.7 which does not have the usual setae. Merus similar to that of large chela, but inferointernal margin terminates in an acute tooth.

Carpal articles of second leg with ratio: 10:4:2:2:5.

Following leg detached, presumed from proportions of paratype to be third. Ischium with spine. Merus 4 times as long as broad, bearing large acute tooth distally on inferior margin. Carpus 0.6 as long as merus; superodistal margin terminating in a rounded tooth, inferodistal margin terminating in a strong acute tooth. Propodus 0.7 as long as merus, bearing on or near inferior margin 3 pairs of spines, 6 single spines and a pair distally; margin also carrying several long slender setae. Dactylus 0.2 as long as propodus, bearing on its inferior surface the vestige of a secondary unguis near the distal one-fifth.

Telson 3 times as long as posterior margin is broad. Spines on dorsal surface heavy, much larger than posterolateral spines, anterior pair of dorsal spines placed anterior to middle. Posterolateral margins or inner uropod bearing some acute spines.

DISCUSSION: In 1922 De Man separated a 37 mm female from Sumatra from a group of 4 specimens that he regarded as *A. euchirus* Dana. We have been able to re-examine this group of specimens through the courtesy of the Zoologisch Museum in Amsterdam and find the two specimens from Aru Island and the specimen from the Bay of Batavia to be *A. serenei* Tiwari (see above). The specimen from Sumatra, however, is plainly different and resembles the specimen from off Cape Jaubert. The two specimens differ only in the tooth on the merus of the third leg which is small in the Sumatra specimen and larger in the Australian. The differences between these two specimens and *A. serenei* are: (1) The rostrum is as long as broad with a rounded tip while in *A. serenei* the rostrum varies from 1.7-2.5 times as long as broad with an acute tip. (2) The dactylus of the large chela of *A. georgei* markedly overhangs the pollex and is longer and more compressed in the distal region than *A. serenei.* (3) The palm of the large chela in *A. serenei* is 1.5 times as high as the fingers while in *A. georgei* it is 2 times. (4) The dactylus of the small chela of the male (our specimen) does not have a hairy crest on the medial surface typical of *A. serenei,* but merely the crest without hairs. (5) Finally, the propodus of the third leg in *A. serenei* bears about 20 spines usually set in pairs while in *A. georgei* there are only 11 spines with only 6 set in pairs. The third leg in *A. serenei* is more hirsute than in *A. georgei.*

This species has none of the outstanding characteristics of *A. euchirus* (given above under the discussion for *A. serenei*).

The differences in characteristics discussed above are subject to variation in other species and we hesitate to describe this species as new. Still we feel the marked difference in the anterior region of the carapace and the distal region of the large chela are sufficient to separate this species. It should be mentioned that De Man's specimen lacks the distolateral spines on the inner uropod and also the strong spine on the posterolateral margins of the outer uropods. These appear to have been broken off.

The species is named for R. W. George of the Western Australian Museum who collected the holotype and who has given us much help with the collections from the Western Australian Museum. The holotype will be placed in the Western Australian Museum and the paratype is at the Zoologisch Museum in Amsterdam.

Alpheus maindroni Coutière
Fig. 62

Alpheus maindroni Coutière, 1898b:133, figs. 2, 2′.

SPECIMENS EXAMINED: 1 specimen from AM P. 11359; 2, BAU 10.

DIAGNOSIS: Rostrum slightly longer than broad at base, reaching not quite to middle of first antennular article. Rostrum with prominent but rounded short carina that extends only to base of eyes. Orbitorostral grooves shallow. Anterior margin of carapace between rostrum and orbital hoods extended as slight arcuate prominences; margins of orbital hoods rounded. Visible part of first and second antennular article equal and third article a little shorter; second article 1.5 times as long as broad. Stylocerite acute, reaching to end of first antennular article. Squamous portion of scaphocerite of moderate width, reaching to middle of third antennular article; lateral tooth prominent and reaching beyond end of third antennular article. Carpocerite 4.3 times as long as broad viewed laterally, reaching length of third antennular article past that article. Inferior margin of basicerite with slender acute tooth.

Large chela compressed, 2.5 times as long as broad, fingers occupying distal 0.3; palm 1.4 times as wide as fingers. Superior saddle reduced, forming a shallow oblique groove, not continuing into medial palmar depression; lateral palmar depression a narrow deep longitudinal groove running distally from *linea impressa* that may or may not join depression of superior saddle. Inferior shoulder rounded, lying at right angles to palm; inferomedial depression a well-defined and U-shaped groove 0.3 height of palmar face; inferolateral depression triangular extending on to palm 0.3 height of the palm. Plunger of dactylus prominent. Merus 2.2 times as long as broad with small acute tooth distally on inferointernal margins.

Small chela not sexually dimorphic, 3.0 times as long as broad, fingers 1.1 times length of palm. Palm bearing rounded tooth medially at dactylar articulation and slightly constricted in width at this point. Medial face of fingers moderately hirsute, bearing numerous scattered patches of short setae interspersed with longer setae. Lateral face of fingers glabrous. Merus similar to that of large chela, 2.5 times as long as broad, bearing acute tooth distally on inferointernal margin.

Ratio of articles of carpus of second leg: 10:4:2:2:4.

Ischium and merus of third leg unarmed; merus 4 times as long as broad. Carpus 0.6 as long as merus, both distal margins slightly projected, inferodistal rounded, superodistal projection acute. Propodus only slighlty longer than carpus, bearing on its

Fig. 62 *Alpheus maindroni* Coutière
20 mm female from BAU 10. **a.** Anterior region, dorsal view; **b.** large cheliped, medial face; **c, d.** large chela and dactylus, lateral face; **e.** small cheliped; **f.** second leg; **g.** third leg; **h.** telson. All figures same scale.

inferior margin 7 slender spines and a pair distally. Dactylus simple, acute, 0.3 as long as propodus.

Telson 2.5 times as long as posterior margin, anterior pair of spines on dorsal surface placed just anterior to midline.

DISCUSSION: This species resembles most closely *A. parvirostris* Dana. However, it lacks the tooth on the merus of the third leg and the prominent inferior tooth on the basicerite. The projections between the rostrum and the orbital hoods are similar to, but smaller than those of *A. parvirostris.* We examined the holotype of *A. maindroni* at the University Museum of Zoology in Cambridge, England. We found our specimens agree very well except the superior saddle of the large chela on the holotype does not continue into the lateral palmar depression but terminates just short of it. We interpret this as an individual difference.

BIOLOGICAL NOTES: The two specimens we personally collected came from the reef flat from dead coral heads. We have one specimen in our collections from the Philippines that appeared to be living commensally with a fire worm (genus *Eurythoe*). Coutière reports the following colour notes. ". . . *faiblement coloré* avec quelques bandes diffuses d'un rouge clair sur le thorax et l'abdomen. Les pinces sont marquées *irrégulièrement de taches blanches et rouges sur la face superiéure ou interne, surtout a l'extrémité des doigts et au bord antéro-distal de la paume"* Our specimens range in size from 15 to 26 mm.

AUSTRALIAN DISTRIBUTION: Two specimens were collected at Green Island, near Cairns, Qld., and one from near Angourie, N.S.W.

GENERAL DISTRIBUTION: Mascate (Gulf of Oman), Djibouti and the southern Philippines.

Alpheus dolerus Banner
Fig. 63

Alpheus dolerus Banner, 1956:362, fig. 21.

SPECIMENS EXAMINED: 1 specimen from AM 74 (AM P. 27472); 3, BAU 29; 7, BAU 32; 4, BAU 56; 1, US 123601.

DIAGNOSIS: Rostrum acute, bearing a few stiff setae on margins, reaching to distal half of first antennular article, with rounded carina continuing posteriorly to slightly behind corneas. Orbitorostral grooves shallow, extending just past base of eyes. Anterior margins of orbital hoods rounded and bearing a stiff seta on margin of orbitorostral concavity. First and second antennular articles subequal, second article twice as long as broad, third article slightly shorter than second. Lateral spine of stylocerite reaching to end of first antennular article. Lateral tooth of scaphocerite reaching beyond end of antennular peduncle, squamous portion reaching to end of peduncle. Carpocerite only slightly longer than peduncle. Lateral spine of basicerite small but acute.

Large chela 2.3 times as long as broad with fingers occupying the distal 0.3. Superior margin with U-shaped saddle; proximal shoulder rounded, not overhanging saddle; distal shoulder gradually rounded. Lateral palmar depression well-defined, quadrangular, continued proximally to *linea impressa.* Medial palmar depression well-defined, triangular, apex reaching middle of palm. Inferior shoulder heavy, rounded and continues as slight shoulder to middle of lateral face. Inferolateral depression shallow, no inferomedial depression. Plunger well developed. Merus 2 times

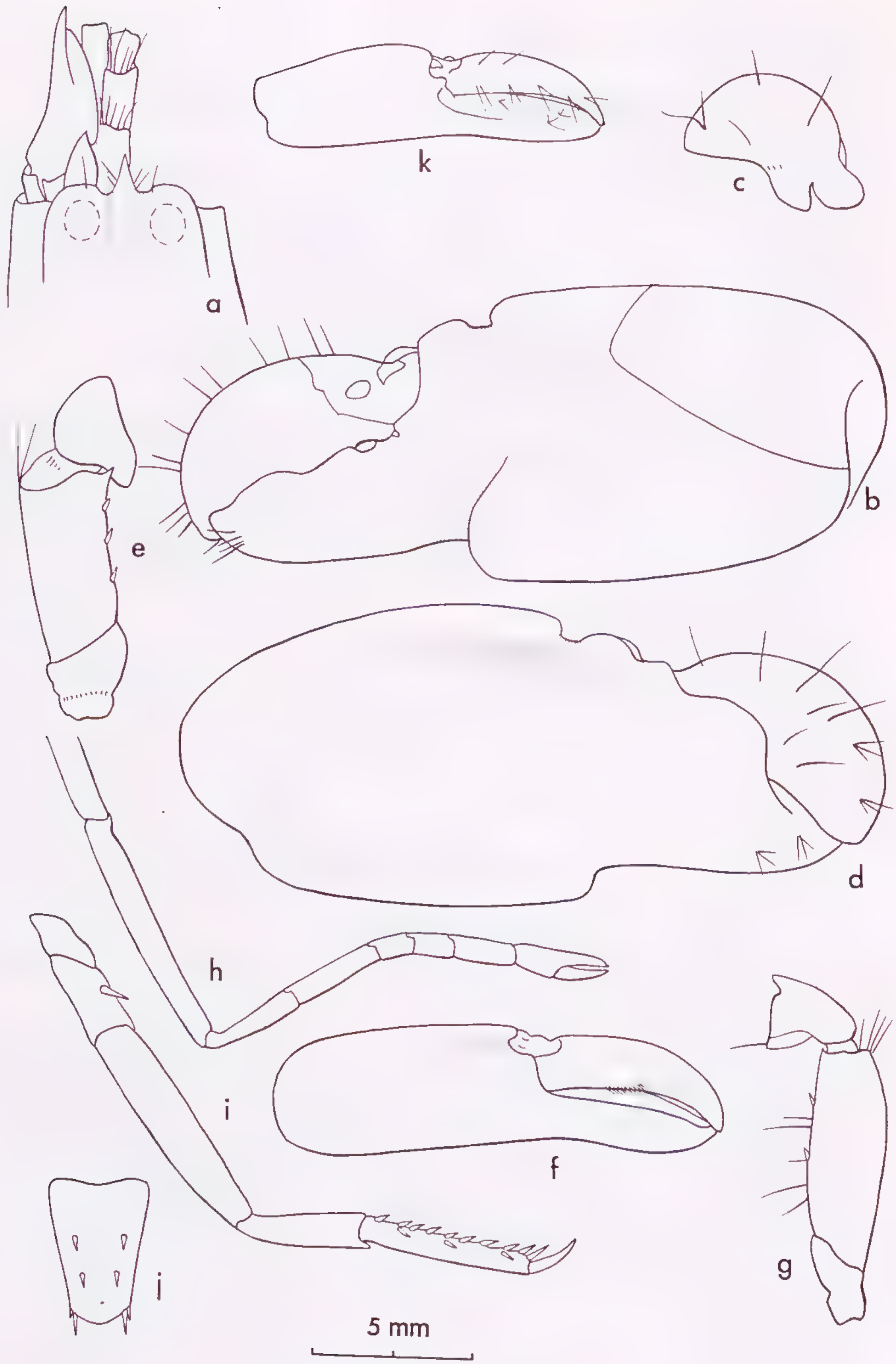

Fig. 63 *Alpheus dolerus* Banner
17 mm male from BAU 29. **a.** Anterior region, dorsal view; **b, c.** large chela and dactylus, lateral face; **d, e.** large chela and merus, medial face; **f, g.** small chela, lateral face, and merus, medial face; **h.** second leg; **i.** third leg; **j.** telson. 16 mm female from BAU 29. **k.** Small chela, lateral face. All figures same scale.

as long as broad, bearing 2 or 3 spines on inferointernal margin and an acute tooth distally.

Small chela of male 3.5 times as long as broad, fingers and palm equal in length. Superior margin of palm proximal to dactylar articulation developed as a rounded ridge flanked by a shallow depression on either side; articulation without teeth. Dactylus slightly expanded proximally on lateral face, with expansion bearing row of short setae. Both finger and pollex bearing knife-like ridges on medial side of oppositive faces that meet when chela is closed; tips somewhat curved and crossing when closed. Merus similar to that of large chela but more slender. Small chela of female more slender, 2.8 times as long as broad, but usually without setiferous crests on dactyl.

Carpus of second legs with ratio: 10:11:4:4:7.

Ischium of third leg bearing strong spine. Merus 4.8 times as long as broad, inermous. Carpus 0.5 length of merus, superodistal and inferodistal margins produced but rounded. Propodus 0.7 as long as merus, bearing 11 spines on or near inferior margin and a pair distally. Dactylus simple, 0.25 length of merus.

Telson 2.4 times as long as posterior margin is broad, posterior margin broadly arcuate. Inner spine of posterior pair much longer than outer.

DISCUSSION: The variation in this species is not marked: 1. The tip of the rostrum may reach from middle to end of first antennular article. 2. The setiferous expansion on the dactyl of the small chela of the male is at times heavier than the one figured (fig. 63f) and we have even seen females with a slightly developed comparable row of setae. 3. The first articles of the second leg may be slightly longer or shorter than the second. 4. Finally, the telson may be somewhat more slender than that described.

This species is most closely related to *A. leptochirus* Coutière which has not been reported from Australia, but the appendages in *A leptochirus* are much more slender. In *A. leptochirus* the large chela is over 3 times as long as broad and the merus of the third leg is 7 times as long as broad. The grooves on the superior and inferior border and the lateral depression much less pronounced. On the small chela of the male the setiferous crests on the dactyl extend around the margins and meet on the superior surface in *A. leptochirus*. Finally, the orbital margins do not bear the 2 stiff setae that are so characteristic of *A. dolerus*.

BIOLOGICAL NOTES: This species has only been collected by breaking up coral heads from not more than 15 ft deep. It is not a large species, the largest specimen in the present collections being only 18 mm long.

AUSTRALIAN DISTRIBUTION: This species has been collected from Diamond Islet in the Coral Sea, south to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: To date this species is known only from Pacific Islands: Marianas, Marshall, Gilbert, Cook and Society Islands; we have some as yet unreported from the Philippines.

Alpheus malabaricus trefzae subspec. nov.
Fig. 64

HOLOTYPE: 18 mm female from Brammo Bay, Dunk Is., (near Tully), northern Queensland. Collected by Shirley Trefz, 2/6/73, from rocky shore in sandy-muddy

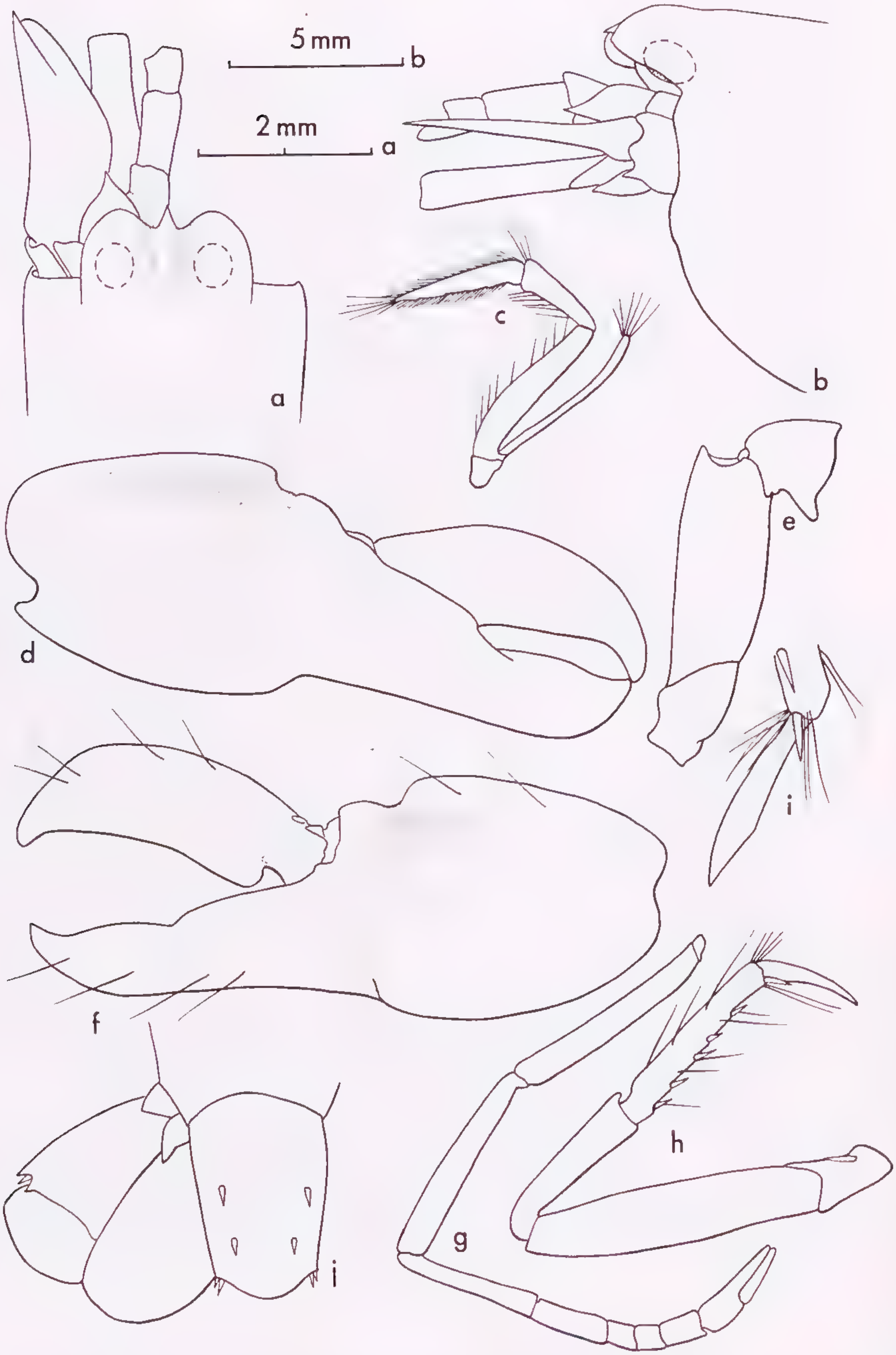

Fig. 64 *Alpheus malabaricus trefzae* subspec. nov.
Holotype (female). **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped, lateral face; **d, e.** large chela and merus, medial face; **f.** large chela, lateral face; **g.** second leg; **h, i.** third leg and enlarged dactylus; **j.** telson and uropods. a, b, c, d, e, f, g, h, j scale a; i scale b.

substrate at 0.0 tide level. (JG 20-73).

DIAGNOSIS: Orbital hoods and rostrum protruding far beyond anterolateral margins of carapace. Orbital hoods inflated, high, rounded; rostrum short, scarcely reaching beyond anterior margin of orbital hoods. Carina short, rounded, reaching only to base of eyehoods; orbitorostral grooves shallow and not extending beyond base of orbits. Visible part of first antennular article 0.7 as long as second; second twice as long as wide; third 0.6 as long as second. Stylocerite acute, reaching to end of first antennular article. Outer margin of scaphocerite slightly concave, lateral tooth reaching well beyond antennular peduncle, squamous portion narrow, only slightly shorter than lateral tooth. Carpocerite reaching only slightly past end of antennular peduncle. Basicerite with acute lateral tooth.

Articles of third maxilliped beginning at base 10:5:7. All articles slender, tip of third article bearing a scant brush of hairs.

Large chela compressed, 2.7 times as long as broad; fingers equal in length to palm, palm 1.4 times wider than fingers when closed. Palm with superior saddle rounded, with proximal shoulder heavy but rounded, distal shoulder evenly rounded and lower than proximal. Lateral palmar depression triangular, well defined, apex reaching to about middle of palm; medial palmar depression faint, bordered on lower margin in proximal part by a slight shoulder, with apex of depression reaching to proximal 0.2 of palm. Inferior shoulder low in profile, rounded, inferolateral depression slight, inferomedial depression lacking. Distal portion of both fingers somewhat hooked and crossing but with tips rounded. Plunger of dactylus low, with distal margin confluent with cutting edge of dactylus. Merus 2.4 times as long as wide, bearing subterminally on inferointernal margin a small acute tooth. Small cheliped missing.

Carpal articles of the second leg with ratio: 10:5:2:2:3; chela as long as sum of last three articles.

Ischium of third leg with spine. Merus unarmed, 5 times as long as broad. Carpus 0.5 as long as merus, superodistal margin slightly projected. Propodus 0.6 as long as merus, bearing on its inferior face 5 spines and a pair distally, interspersed with long setae. Superior margin also bearing many long setae. Dactylus 0.4 as long as propodus, spatulate and slightly excavate on its inferior surface.

Telson twice as long as posterior margin is broad, base 1.4 times as broad as tip; tip strongly convex; anterior pair of dorsal spines placed at middle, posterolateral spines small. Articulation of the outer uropod nearly straight.

DISCUSSION: The following four subspecies of this nominate species have been separated: *A. m. malabaricus* Fabricius from the Malabar coast of India; *A. m. dolichodactylus* Ortmann from Tokyo Bay; *A. m. leptopus* De Man from Indonesia; and *A. m. songkla* B&B from peninsular Thailand. In addition *A. m. mackayi* B. was described from the Hawaiian Islands, but it was later elevated to specific rank (B&B, 1974:428). These subspecies differ one from another in a series of characteristics such as the size of the rostrum, the armature of the merus of the large cheliped and the proportions of the third legs; however, the principal difference was found in the proportions of the small cheliped and the shape of its fingers. As this Australian form is lacking the small cheliped, contrast cannot be made upon this point. The most important difference appears to us to be in the proportions between the fingers and the palm of the large chela which in this subspecies are approximately equal, but in the other subspecies the palm varies from 1.3-2.2 times the length of the fingers. In all other subspecies the rostrum reaches well beyond the orbital hoods, and in all except *A. m. songkla* the merus of the large chela has

a terminal rather than a subterminal tooth while in *A. m. songkla* this tooth is absent. Finally, in *A. m. songkla* and the Australian subspecies the first two carpal articles of the second leg bear the ratio of approximately 10:5 while in the others these articles are approximately equal.

BIOLOGICAL NOTES: Most, if not all, of the forms of this species have been reported from muddy and usually estuarine conditions (*A.m. malabaricus* "From the backwater at Pulicat (India) and apparently burrowing in a muddy bottom" Henderson (1893:434); *A. m. dolichodactylus* from "Tokyo Bay"; *A. m. leptopus* from various types of muddy bottoms from 18-289 metres; *A. m. songkla* from the muddy bottom of a shallow brackish water lake. *A. mackayi* came from the muddy bottom of a brackish Hawaiian fishpond.) Dr Shirley Trefz described the habitat on Brammo Bay, Dunk Island as having a substrate with a mixture of sand and mud, not so soft that a person walking would sink into it more than a centimetre or so; there were no permanent streams on Dunk Island, but at the time of her visit after heavy rains, there appeared to be brackish water seeping onto the beach at low tide from an island freshwater lens. At the time of her visit the waters around Dunk Island were heavy with sediments, presumably from the rains. The specimen was collected from a burrow under a rock on the substrate either in the lowest intertidal or the immediate subtidal zone (the island was visited at a period of neap tides).

The subspecies is named in honour of Dr Shirley Trefz of Leeward Community College, Honolulu, Hawaii, our personal friend who has often supplied us with specimens. The holotype will be placed in the Australian Museum, Sydney, N.S.W.

GENERAL DISTRIBUTION: The other subspecies are known from East Africa to Hawaii, but have not been collected from Australia.

Alpheus macrodactylus Ortmann
Fig. 65

Alpheus macrodactylus Ortmann, 1890:473, pl. 36, fig. 10. De Man, 1898b:321, pl. 4, fig. 4.

Nec Alpheus macrodactylus Coutière, 1898c:196. (See below).

Previous Australian record:
Ortmann, *loc. cit.* Sydney N.S.W.

SPECIMENS EXAMINED: 3 specimens from AM P. 4288.

DIAGNOSIS: Rostrum slender, longer than broad at base, with slightly rounded carina; orbitorostral grooves not deep and disappearing at base of eyes. Anterior margins of orbtial hoods convex, orbitorostral margins recessed at base of rostrum. Second antennular article 1.3 times longer than visible part of first antennular article and twice as long as broad; third article 0.5 as long as second. Stylocerite acute, reaching near end of first antennular article. Squamous portion of scaphocerite moderately broad, reaching to end of antennular peduncle, lateral tooth a little longer. Carpocerite stout, 3.2 times as long as broad, reaching to end of antennular peduncle. Basicerite with small acute lateral tooth.

Large chela 2.3 times as long as broad, fingers as long as palm. Superior saddle broad and shallow. Proximal and distal shoulders gradually rounded. Lateral palmar depression shallow, quadrangular, reaching to *linea impessa*. Medial palmar depression a well-defined narrow triangle with apex almost reaching to proximal end of palm. Inferior shoulder pronounced, rounded, making less than a right angle to lower margin of palm.

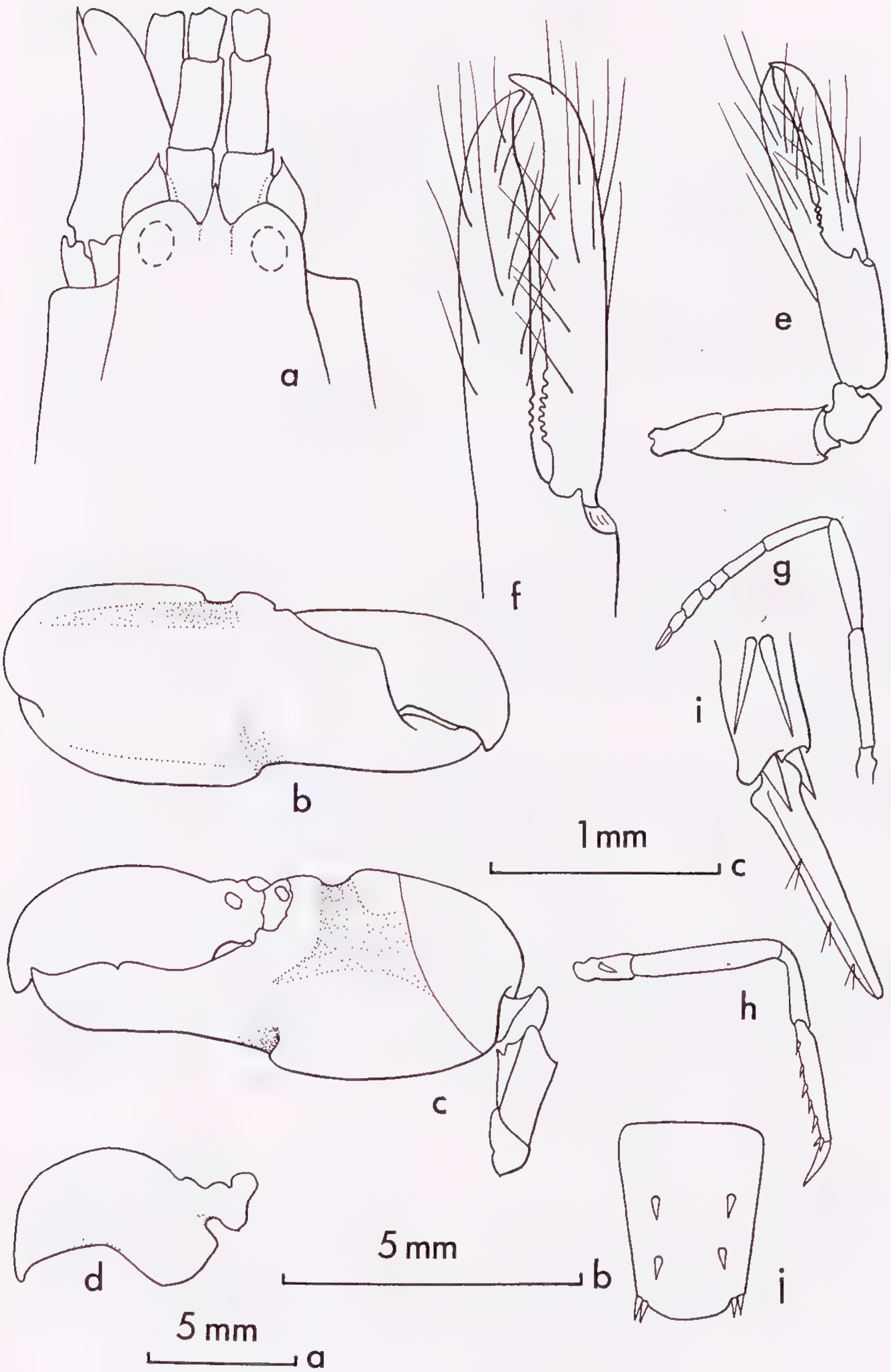

Fig. 65 *Alpheus macrodactylus* Ortmann
35 mm male from AM P. 4288. **a.** Anterior region, dorsal view; **b.** large chela, medial face; **c, d.** large cheliped and dactylus, lateral face; **e, f.** small cheliped medial view and enlarged distal region; **g.** second leg; **h, i.** third leg and enlarged dactylus; **j.** telson. b, c, d, e scale a; a, f, g, h, j scale b; i scale c.

Inferior notch continues into lateral and medial face as faint rounded grooves about 0.2 width of palm. Plunger of dactylus pronounced. Merus 2.0 times as long as broad, bearing a sharp tooth distally on inferointernal margin.

Small cheliped not sexually dimorphic, 5 times as long as broad. Fingers 1.7 times longer than palm, palm without sculpture, but bearing small tooth on medial side of dactylar articulation. Oppositive face of dactylus near articulation bearing 7 rounded teeth in low crest, meeting but not meshing with teeth on pollex opposite; both oppositive faces bearing scattered long, forward-directed setae that cross. Tips of fingers hooked and crossing.

Second leg with ratio of carpal articles: 10:6:2:2:4.

Ischium of third leg with spine. Merus 5 times as long as broad and unarmed. Carpus 0.5 as long as merus with inferior and superior margins projecting distally but rounded. Propodus 0.8 as long as merus, bearing 5 spines on inferior margin and a pair distally. Dactylus 0.4 as long as propodus, trigonal, inferior surface flattened.

Telson broad, 1.6 times as long as broad posteriorly. Anterior pair of dorsal spines placed slightly anterior to midline.

DISCUSSION: We have been able to examine the holotype at the Musée Zoologique de l'Université et de la Ville, Strasbourg, France and find our specimens agree with it. Ortmann stated that the fingers of the small chela were in contact when closed the full length *"dicht zusammenschleissend"*, but in the examination of the type we found they were agape, curved and crossed at their tips the same as in our specimen.

We do not believe that the specimens from the Leiden Museum discussed by Coutière (1897c:196) under this name are actually of this species; however, we have to base our opinion upon the description he has given as we could not find the specimens either in Leiden or Paris. The brief description of the first two specimens he discusses, those without the chelipeds and without indication of locality, would fit *A. euphrosyne euphrosyne* De Man better. Apparently the next group of specimens (8 from Bangkok, one from Suez and one from "Pescabury") all show sexual dimorphism in the small chelae and have the second carpal article of the second leg one-fourth the length of the first; both of these characteristics rule out the possibility of the specimens being *A. macrodactylus*. The final four specimens from Bangkok in which the lobe proximal to the superior saddle is *"presque aigu"* and the sculpturing on the palm of the small chela is marked, also cannot be this species. However, without the specimens to examine, we do not wish to guess what species they may be.

BIOLOGICAL NOTES: Previous records of this species have not indicated the type of habitat, and the collection cited above gives merely "Finches Bay, Cooktown, Qld" (which is not shown on sheets 1 or 2 of "Strip Map, Great Barrier Reef and Adjacent Islands"). However, we have some specimens in our personal collections, previously unreported, from Guam collected by H. Kami that come from the mouth of a river. The spatulate condition of the dactyli of the walking legs would lead one to presume the species lives in soft, probably muddly, bottoms. Our largest specimen was 33 mm in length.

AUSTRALIAN DISTRIBUTION: As mentioned the specimens came from Cooktown, Qld. The type location is Sydney, N.S.W.

GENERAL DISTRIBUTION: Ceylon; Annam; Formosa; Guam (see above).

Alpheus bunburius sp. nov.
Fig. 66

HOLOTYPE: 38 mm female from Bunbury, W.A. Collected by W. H. Butler, March, 1962 (WM 271-65).

DIAGNOSIS: Rostrum triangular, acute, slightly longer than broad, reaching to distal quarter of first antennular article. Orbitorostral magins concave; rostral carina slight; orbitorostral grooves shallow. Orbital hoods somewhat inflated. First and third antennular articles subequal, second article 1.6 times as long as visible portion of first and twice as long as broad; lateral margins armed with setiferous bristles. Stylocerite acute, reaching to end of first antennular article, lateral margins bearing setiferous bristles. Scaphocerite with squamous portion narrow, reaching to end of antennular peduncles, lateral tooth a little longer. Carpocerite reaching almost length of third article past that article. Basicerite with small but acute lateral tooth.

Ratio of articles of third maxilliped: 10:4:8.

Large chela 3 times as long as broad. Fingers heavy, distally rounded, almost equal to palm in length and breadth, plunger of dactylus low and confluent with distal margin. Superior saddle shallow, proximal and distal shoulders gradually rounded. Lateral palmar depression shallow, forming a quadrangular groove that disappears at *linea impressa*. Medial palmar depression slight, triangular, with inferior margin of depression marked by a strong shoulder. Inferior shoulder not projecting, rounded; inferior notch continues into lateral face in a slight triangular depression. Distal two-thirds of medial face of chela armed with sparsely set long hairs. Merus inermous, 2.7 times as long as broad.

Small chela of female not balaeniceps, 4.3 times as long as broad, fingers slightly longer than palm. Medial side of dactylar articulation with small blunt tooth. Distal two-thirds of chela with scattered hairs on medial face similar to large chela. Merus inermous, 3.0 times as long as broad.

Second leg with ratio of carpal articles: 10:5:3:3:4.

Third leg missing. Ischium of fourth leg inermous, 0.5 length of merus. Merus 4.7 times as long as broad, inermous. Carpus 0.6 as long as merus with superodistal margin projecting; inferodistal margin rounded and bearing a long seta. Propodus 0.8 as long as merus, bearing 5 spines on inferior margin and a pair distally, interspersed with long setae, superior margin bearing long setae. Dactylus trigonal in section, slightly curved, with inferior suface flattened but not broadened.

Telson 1.6 times as long as wide at posterior margin, posterior margin arcuate. Dorsal and posterolateral spines small.

DISCUSSION: In the Edwardsii Group there is only one species and one subspecies in which the fingers of the large chela are equal or almost equal to the length of the palm; these are *A. macrodactylus* Ortmann and *A. malabaricus trefzae* subspec. nov. *A. macrodactylus* has a trigonal dactylus of the third legs as does this species, but it differs markedly in the form of the chelipeds. In Ortmann's species the fingers of the small chela are markedly longer than the palm and bear numerous teeth proximally, while on the large cheliped the palm is heavier with more extensive depressed areas on both faces, the plunger of the dactylus is heavier and the merus bears a tooth (see fig. 65 b-f). *A. bunburius* is quite similar to *A. malabaricus trefzae* in the large chela (unfortunately, the small cheliped of that subspecies is unknown) but in *A. malabaricus trefzae* the merus bears a small but definite tooth; moreover, the dactylus of the third leg in *A. malabaricus*

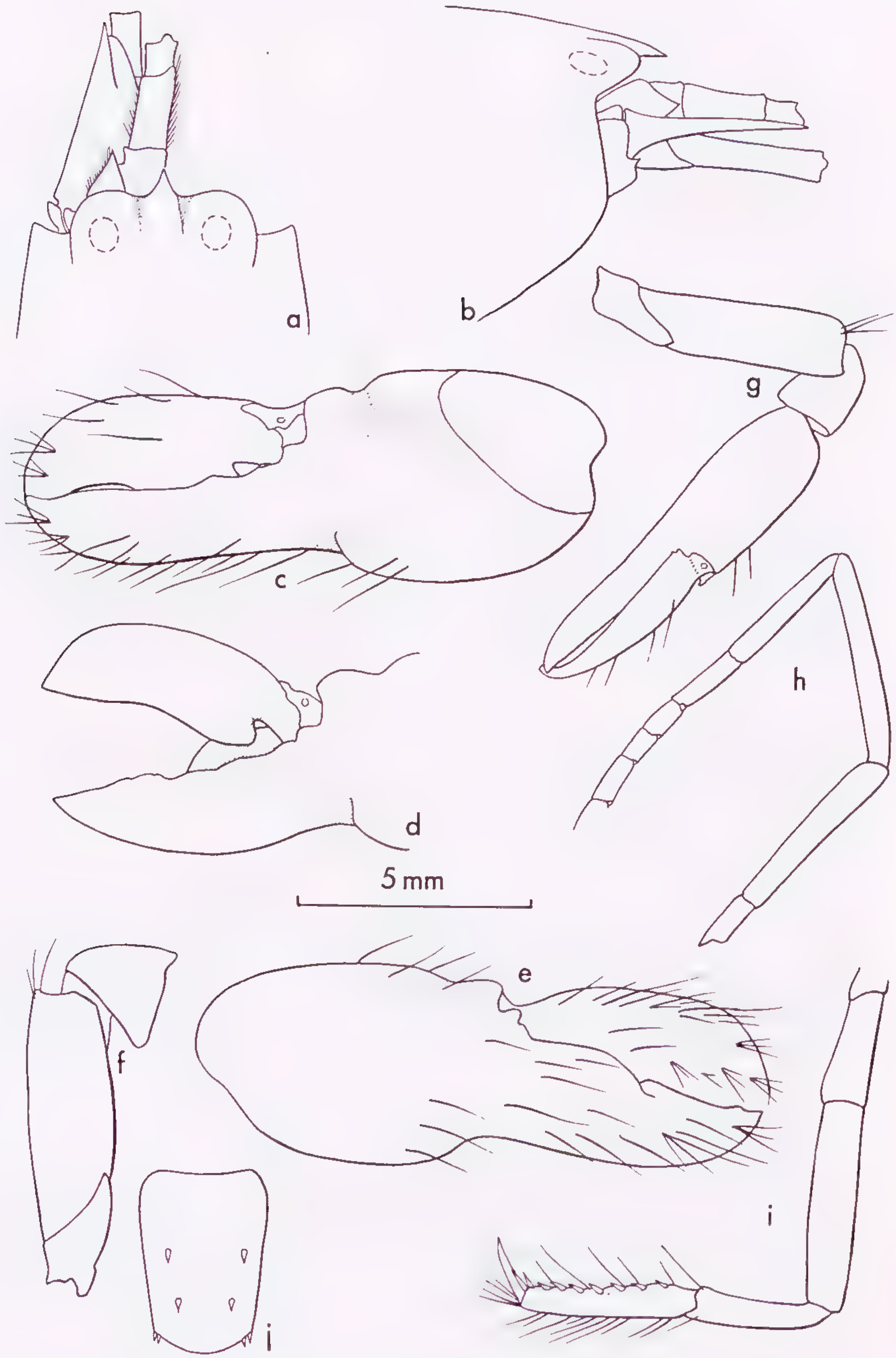

Fig. 66 *Alpheus bunburius* sp. nov.
Holotype (female). **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and detail of dactylus, lateral face; **e, f.** large chela and merus, medial view; **g.** small cheliped, lateral view; **h.** second leg; **i.** fourth leg; **j.** telson. All figures same scale.

trefzae is not trigonal but definitely subspatulate.

In general the form of this species is very similar to *Alpheus euphrosyne euphrosyne* De Man and *A. euphrosyne richardsoni* Yaldwyn, but in addition to the differences in the palmar/finger length this species differs in the low plunger of the dactylus of the large chela and the trigonal dactylus of the third legs.

This species is named for the place in Western Australia where it was collected. The holotype will be placed in the Western Australian Museum.

Alpheus tasmanicus sp. nov.
Fig. 67

HOLOTYPE: 22 mm male from MM 161. Collection notes state only the specimen was from Tasmania.

DESCRIPTION: Rostrum acute, 1.8 times as long as broad at base and reaching to middle of visible part of first antennular article. Rostral carina low, rounded, reaching to base of eyes. Orbitorostral grooves shallow. Anterior margin of orbital hoods only slightly rounded, with slight concavity towards rostral base. Second antennular article 1.7 times as long as broad, slightly longer than visible part of first, third a little shorter than first. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with outer margin slightly concave, lateral tooth reaching almost length of third article past that article, squamous portion moderately broad, reaching just proximal to lateral tooth. Carpocerite as long as lateral tooth of scaphocerite. Basicerite with prominent acute tooth.

Ratio of articles of third maxilliped: 10:2.5:6.

Chela 2.6 times as long as broad with fingers occupying distal 0.4. Superior saddle well defined with proximal shoulder at right angles to, not overhanging, saddle; distal shoulder gradually rounded and lower than proximal shoulder. Lateral palmar depression well defined, quadrangular, extending to *linea impressa*. Medial palmar depression triangular with apex reaching to middle of palm. Inferior shoulder heavy but rounded. Inferior groove moderate, extending into lateral face as a shallow triangle and into medial face as shallow, ill-defined depression. Lateral face of palm carrying shallow rounded depression extending from level of middle of superior depression to a triangular apex at level of distal end of socket of fixed finger; this depressed area is separated by rounded ridges from both superior and inferior depressions. Lower surface of palm flattened. (Note: exoskeleton of specimen soft due to recent moulting; the last two features may be the result of distortion). Plunger of dactylus low, distal margin confluent with cutting edge. Merus 1.8 times as long as wide and distally inermous.

Small chela presumably not sexually dimorphic, 4 times as long as high and fingers are 1.3 times as long as palm. Medial face of palm and fingers bearing long forward-sweeping hairs, sparsely placed. Merus 2.5 times as long as broad and inermous distally.

Carpal articles of second leg with ratio: 10:4:2:2:4.

Ischium of third leg with spine. Merus inermous, 4 times as long as broad. Carpus 0.5 as long as merus, distal margins terminating in obtuse projections. Propodus 0.7 as long as merus, bearing on its inner face 9 spines and a pair distally. Dactylus conical, almost half as long as propodus.

Telson 2.3 times as long as posterior margin is broad. Anterior pair of dorsal spines

Fig. 67 *Alpheus tasmanicus* sp. nov.
Holotype (male). **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped, lateral face; **d, e.** large chela and dactylus, lateral face; **f, g.** large chela and merus, medial face; **h.** small cheliped, medial face; **i.** second leg; **j.** third leg; **k.** telson. All drawings same scale.

placed anterior to middle. Posterolateral spines smaller than dorsal.

DISCUSSION: This species is most probably related to the species in the Edwardsii Group in which the small chela of neither the male nor the female is balaeniceps. We have only the male, but in no species known does the female carry a balaeniceps datcylus when the male does not. The following species are included in this group, and may be differentiated from this species as follows: *A. bisincisus* De Haan which has a flattened rather than a rounded rostral carina; *A. hululensis* Coutière, which has the superior depression on the medial face of the large chela in the form of a "U" rather than a triangle; *A. pacificus* Dana, which has the proximal shoulder of the superior saddle of the large chela overhanging the saddle rather than at right angles; further the rather dense hairs between the fingers of the small chela in *A. pacificus,* here are reduced to a sparse condition; *A. haanii* Ortmann, which, like *A. pacificus,* has a proximal shoulder overhanging the groove on the large chela and both chelipeds carry teeth distally on their meri; *A. macrodactylus* Ortmann, *A. malabaricus malabaricus* Fabricius, *A. m. songkla* B&B and *A. mackayi* B which have spatulate dactyli on the third leg, rather than trigonal; moreover, the fingers of the small chela are approximately 1.7 to 2.0 the length of the palm in the four species, rather than 1.2 times the palmar length as in this species.

This species has been named for the place from where it was collected. The holotype will be placed in the Australian Museum, Sydney, N.S.W.

Alpheus pacificus Dana
Fig. 68

Alpheus pacificus Dana, 1852:544, pl. 34, fig. 5. Coutière, 1905a: 909, fig. 47. Tiwari, 1963:315, fig. 30. Banner and Banner, 1966b:143, fig. 54.
Crangon pacifica Banner, 1953:138, fig. 50. (Neotype established).
Alpheus gracilidigitus Miers, 1884:287.
Previous Australian records:
Nobili, 1899:233, Double Bay, N.S.W. (as *A. gracilidigitus).*
Gillett and Yaldwyn 1969:70, 110, fig. 41. Heron Is., Qld.

SPECIMENS EXAMINED: 1 specimen from AC 39; 1, AC 40; 1, AC 78; 1, AC 79; 2, AM 52 (AM P. 27515); 3, AM 53 (AM P. 27516); 1, AM 78 (AM P. 27886); 1, AM 80 (AM P. 27308); 1, AM 88 (AM P. 27309); 2, AM 89 (AM P. 27310); 7, AM 93 (AM P. 27889); 3, AM 104 (AM P. 27311); 2, AM 107 (AM P. 27519); 2, AM 108 (AM P. 27312); 5, AM 113 (AM P. 27463); 1, AM 120 (AM P. 27520); 9, AM 123 (AM P. 27313); 2, AM 153 (AM P. 27456); 1, AM 164 (AM P. 27557); 2, AM 192 (AM P. 27853); 2, AM 205 (AM P. 27887); 1, AM 211 (AM P. 27888); 1, AM 240 (AM P. 27568); 2, AM 243 (AM P. 27314); 1 AM 246 (AM P. 27466); 3, AM 290 (AM P. 27361); 1, AM 311 (AM P. 27437); 1 AM 328 (AM P. 27362); 1, AM 339 (AM P. 28167); 2, AM P. 1182; 2, AM P. 1183; 2, AM P. 1649; 1, AM P. 2220; 3, AM P. 4229; 4, AM P. 4996; 3, AM P. 5277; 1, AM P. 5710; 1, AM P. 6350; 1, AM P. 6495; 2, AM P. 6863; 1, AM P. 7027; 2, AM P. 8963; 1, AM P. 10311; 1, AM P. 10784; 1, AM P. 12920; 1, AM P. 13555; 12, AM P. 13571; 5, AM P. 13574; 1, AM P. 27407; 1, AM P. 27408; 3, AM P. 27432; 1, AM P. 27765; 1, AM P. 27767; 3, AM P. 27878; 1, BAU 15; 2, BAU 54; 7, BAU 56; 5, BAU 58; 1, JC 17; 1, JC 18; 1, JC 22; 1, JC 24; 1, JC 25; 1, JC 31; 1, JG 21-73; 1, MM 108; 1, UQ 16; 3, US 123572; 2, US 123573; 3, US 123574; 2, US 123575; 1, US 123576; 23, US 123587; 1, VM 25; 1, WM 43-65; 1, WM 96-65; 6, WM 204-65.

DIAGNOSIS: Rostrum reaching just past middle of visible part of first antennular article, bearing a few short setae on lateral margins. Orbital hoods slightly inflated, orbitorostral grooves moderately deep and reaching posterior to eyes. Anterior margin

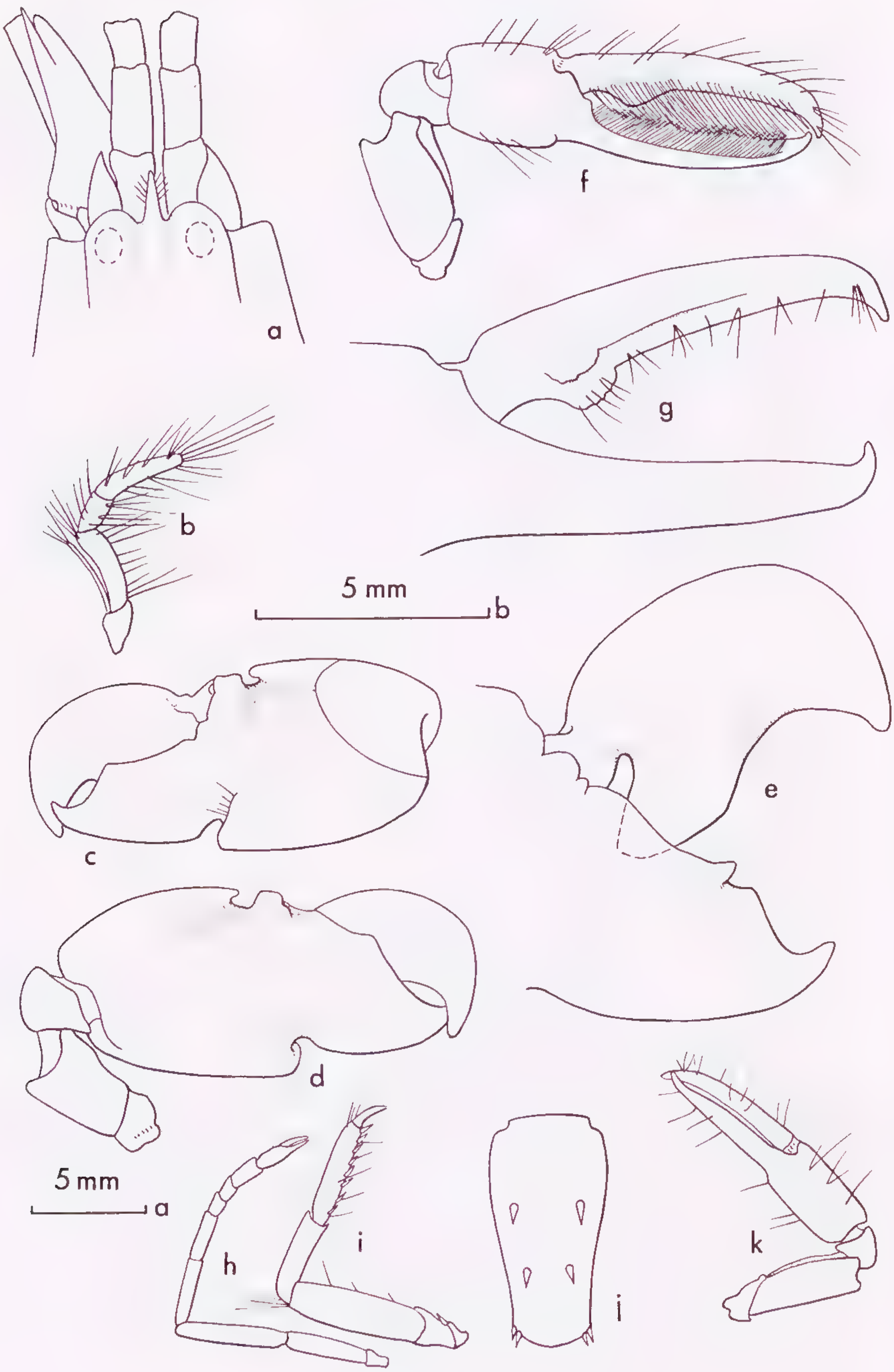

Fig. 68 *Alpheus pacificus* Dana
40 mm male from AM 211. **a.** Anterior region, dorsal view; **b.** third maxilliped; **c.** large chela, lateral face; **d, e.** large cheliped and enlargement of distal region, medial face; **f, g.** small cheliped and enlargement of distal region (with setae removed), lateral face; **h.** second leg; **i.** third leg; **j.** telson. 36 mm female from AM 53. **k.** Small cheliped. b, c, d, f, h, i, k scale a; a, e, g, j scale b.

of orbital hoods rounded. Second antennular article 2.2 times as long as broad and 1.5 times longer than visible part of first antennular article. Third antennular article subequal to visible part of first article. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with outer margin slightly concave, lateral tooth reaching past antennular peduncle; squamous portion narrow, slightly shorter than lateral tooth. Carpocerite as long as lateral tooth of scaphocerite. Lateral tooth of basicerite broad at base, as long as stylocerite.

Apex of ultimate article of third maxilliped bearing many long slender setae.

Large chela 2.2 times as long as broad, fingers occupying the distal 0.4. Superior saddle well defined with proximal shoulder rounded, overhanging; distal shoulder strong and abrupt. Lateral palmar depression well defined, quadrangular, extending to *linea impressa*. Medial palmar depression triangular, reaching proximally just past middle of palm. Inferior shoulder heavy, rounded, slanted distally. Inferior notch deep, in profile forming a "U". Inferolateral depression a well-defined "V"-shaped groove which continues up face of palm for 0.3 total width. Inferomedial depression "V"-shaped, broad and not well defined. Plunger of dactylus long. Distal margin of socket for plunger in pollex protrudes as a small rounded tooth (diminished in small males and in females). Merus 2.3 times as long as broad, lacking teeth on inferior margins, superior apex projecting but rounded.

Small chela of male 3.7 times as long as broad with fingers varying from 1.5-2.2 times as long as palm. Inferior margin of palm carrying a rounded to abrupt shoulder below dactylar articulation. Both fingers curved, slender and with acute tips. Dactylus not balaeniceps, bearing on lateral cutting edge a dense series of long, forward-sweeping setae that cross a similar series of setae on pollex. Cutting surface of dactylus with two thin crests near articulation, the larger crest placed in the middle of cutting surface and fitting into shallow groove in pollex when fingers are closed; the smaller near medial edge, not touching pollex when fingers are closed; fingers with tips overlapping, but gaping between tips and dactylar crests when closed. Crests smaller or lacking in immature males and females. Chela of females smaller, with fingers 1.2-1.5 times as long as palm and bearing only scattered setae instead of rows of long hairs. In both sexes carpus cup-shaped, bearing subacute tooth on superodistal margin. Merus similar to that of large chela.

Carpal articles of second leg with ratio of: 10:8:2:2:5.

Ischium of third leg with spine. Merus inermous, 4.0 times as long as broad, inferior margin bearing a few stiff setae. Carpus 0.4 as long as merus, superior margin somewhat extended distally, inferior margin produced as a subactue tooth and bearing two setae. Propodus 0.7 as long as merus, bearing on its inferior margin 8 spines. Dactylus simple, 0.3 as long as propodus.

Telson 2.0 times as long as broad, lateral margins constricted near posterior section. Posterolateral spines feeble, posterior margin slightly arcuate.

DISCUSSION: This species has been discussed and depicted many times. We only want to add here that we found in the small chelae of our male specimens a greater variation in the ratio of the fingers to palm than has previously been reported. In 20 males varying from 20-40 mm in length the fingers varied from 1.2-2.0 times as long as palm. In fact, we found one 40 mm male specimen from Queensland (JC 22) and also a specimen from the northern Indian Ocean in our collections in which the fingers of the small chelae were 2.5 times as long as the palm. There was no correlation between the size of the specimen and the finger-palm ratio. We have re-examined the small chelae of some of the

male specimens of *A. pacificus* from Hawaii and find they have only minimal crests on the cutting surface of the dactylus.

BIOLOGICAL NOTES: This species is largely intertidal, living under rocks. It has been collected from dead coral in water up to 20 metres. In Hawaii we have found this species characteristically burrowing in clean sand, under rocks and coral heads in areas of moderate surf (B&B, 1974); all we personally collected in Australia seemed to have come from similar habitats on reef flats.

From a colour photograph taken by Keith Gillett, an associate of the Australian Museum, of a specimen of *A. pacificus* collected by J. C. Yaldwyn from Heron Island we have made the following colour notes: Tip of large chela brown, rest of fingers and palm banded with irregular white, olive green and blue green. Fingers of small chela light green, distal three-fourths of palm white and olive green at base. Carpus and dactylus blue. Thoracic legs blue with white band at meral-carpal joint. Antennae blue, antennules olive green. Scaphocerite and carpocerite blue. Carapace and abdomen reddish brown with faint brown line extending from middle of carapace to sixth abdominal somite. On the lateral margins where each abdominal somite meets the next is a diffuse white spot. Telson same colour as abdomen, uropods light green. In Hawaii we have found the colour pattern and intensity in this species varies in the same locality and may also change when a specimen is moved from its habitat to an aquarium. Our specimens ranged up to 40 mm in length.

AUSTRALIAN DISTRIBUTION: In Western Australia this species has been collected from Perth to Northwest Cape; in northern Australia from the Gulf of Carpentaria; in eastern Australia from off Cooktown, Qld. to Sydney, N.S.W. We have also examined specimens from Lord Howe and Norfolk Islands.

GENERAL DISTRIBUTION: This species has been reported throughout the Indo-Pacific area from the Red Sea and Madagascar to Clipperton Island in the far eastern North Pacific. We have also seen specimens from Mombasa, Kenya. Its type locality is Hawaii.

Alpheus heronicus sp. nov.

Fig. 69

HOLOTYPE: 28 mm female from Heron Is., Capricorn Group, Qld. Collected by Julie Booth, 1965, AM 390, (AM P. 27235). (Probably intertidal).

PARATYPES: 4 females from the same location as the types, 20-30 mm, (AM P. 27236); 2 females, 16, 27 mm from Moreton Bay, J. S. Hynd collection, 19/5/46, trawled below low water mark, AM 70 (AM P. 27214).

DIAGNOSIS: Rostrum a little longer than broad, reaching just past middle of visible part of first antennular article, bearing on lateral margins a few stiff setae. Rostral carina rounded, extending to base of eyes, orbitorostral grooves moderately deep. Anterior margin of orbital hoods gradually rounded, with a shallow concavity at base of rostrum. Visible part of first and third antennular articles subequal, second article 1.5 times as long as third, 2 times as long as broad. Stylocerite acute, reaching end of first antennular article. Scaphocerite with squamous portion reaching to end of antennular peduncle, lateral tooth reaching to end of carpocerite; carpocerite exceeding length of antennular peduncles almost by length of third article. Basicerite bearing slender lateral tooth.

Ratio of articles of third maxilliped: 10:3:6.6.

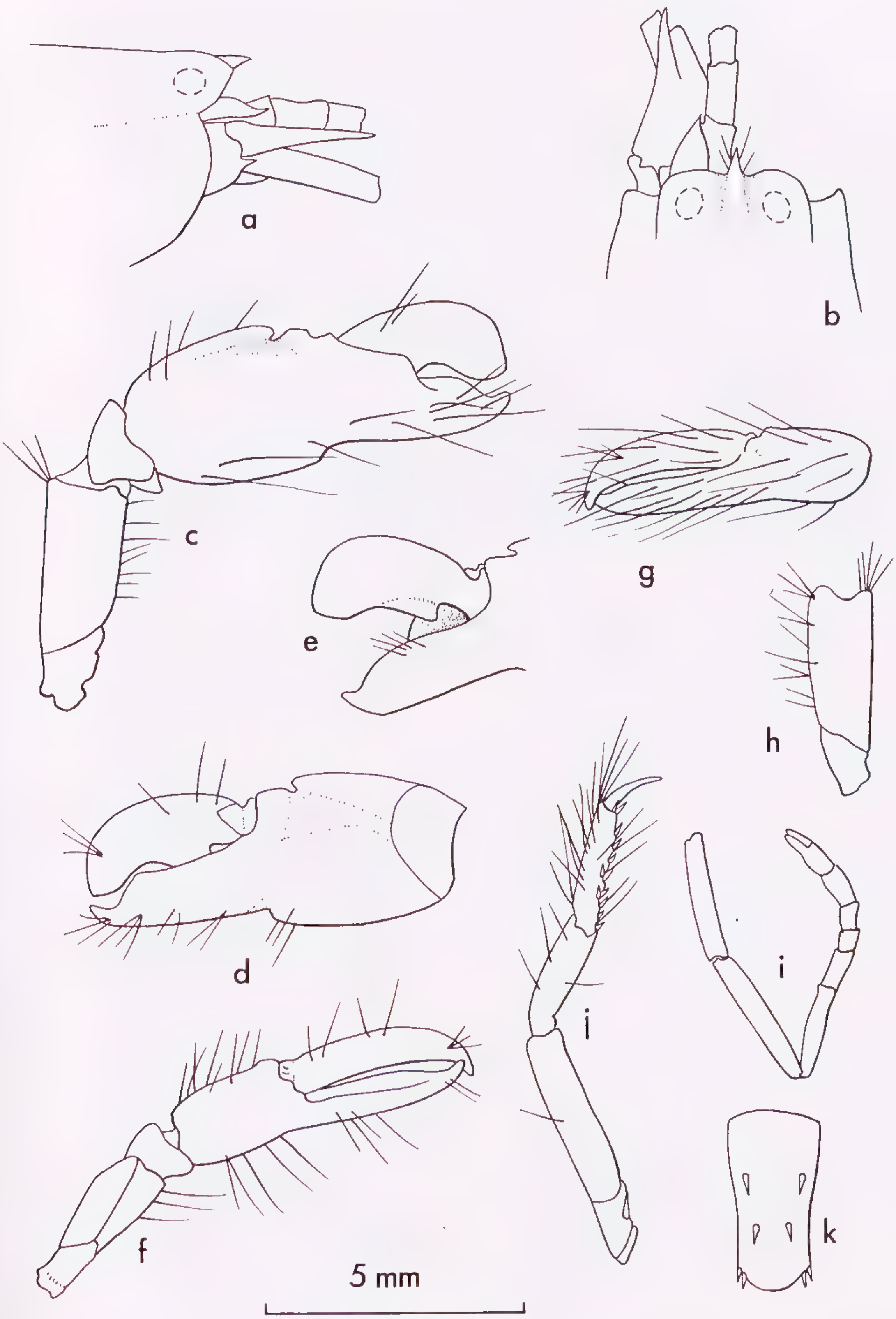

Fig. 69 *Alpheus heronicus* sp. nov.
Holotype (female). **a, b.** Anterior region, lateral and dorsal view; **c.** large cheliped, medial face; **d, e.** large chela and detail of plunger, lateral face; **f.** small cheliped, lateral face; **g, h.** small chela and merus, medial face; **i.** second leg; **j.** third leg; **k.** telson. All figures same scale.

Large chela 2.6 times as long as broad with dactylus occupying the distal 0.4. Proximal shoulder rounded, overhanging superior saddle, distal shoulder gradually rounded. Superior saddle continuing into lateral face as a quadrangular depression which extends to *linea impressa.* Medial palmar depression a narrow triangle with apex almost reaching to proximal quarter of palm. Inferior shoulder low and rounded, continuing as slight depression on lateral face. Plunger of dactylus developed only as a low crest, confluent with cutting edge. Merus 2.2 times as long as broad; distal margins inermous, but bearing setae on superodistal margin and along inferointernal margin.

Small chela of female 4.2 times as long as broad with finger 1.5 times longer than palm, without sculpture except for small depression on superior margin proximal to articulation of dactylus. Medial face of chela beset with many long fine setae; neither dactylus nor pollex with setiferous crests. Merus 2.4 times as long as broad, without teeth distally. Male small chela unknown.

Second legs with ratio of carpal articles: 10:4:2:2:3.

Ischium of third leg carrying a strong spine. Merus inermous, 4.5 times as long as broad. Carpus 0.6 as long as merus, with subacute superodistal projection and acute inferodistal projection. Propodus 0.6 as long as merus, bearing on its inferior margin 10 spines and a pair distally interspersed with long setae and with long setae on superior margin. Dactylus simple, slender, 0.5 as long as propodus.

Telson with width anteriorly 1.3 times that of tip and 2.3 times as long as broad posteriorly. Anterior pair of dorsal spinules set just anterior to middle. Inner spine of posterolateral pair a little more than 2 times as long as outer.

DISCUSSION: The ratio of the first 2 articles of the second legs in our specimens varies from 10:4 to 10:6. The merus of the third leg varies from 4.2 to 5.0 times as long as broad.

This species is related to the species in the Edwardsii Group in which the meri of the chelipeds are unarmed distally. This includes in Australia *A. euphrosyne euphrosyne* De Man, *A. e. richardsoni* Yaldwyn, *A. inopinatus* Holthuis and Gottlieb, *A. sudara* B&B, *A. australiensis sp. nov., A. bunburius sp. nov., A. pacificus* Dana and two Indo-Pacific species *A. microrhynchus* De Man, and *A. paludicola* Kemp. It differs from all except *A. pacificus* by having the proximal shoulder of the large chela overhanging the superior saddle but unlike *A. pacificus* the inferior shoulder is not projected forward but is no more than a right angle to the plane of the chela. From other individual species other differences occur: from *A. inopinatus* it differs by the minimal development of the inferior shoulder of the large chela; from *A. sudara* by the lack of markedly concave lateral margins of the scaphocerite; from *A. e. euphrosyne* and *A. e. richardsoni* by the lack of a spatulate dactylus on the third leg; from *A. bunburius* by the shorter fingers on the large chela and finally from *A. australiensis* by the lack of setiferous crests on the dactylus of the small chela. This species is close to *A. pareuchirus pareuchirus* Coutière, but that species has strong teeth on the meri of the chelipeds and it also differs in the breadth of the superior saddle, the ratio of the lengths of the first two carpal articles of the second leg, further the proportions of the third legs are more slender. The relationship of this species within the Edwardsii Group would be more certain with knowledge of the male small cheliped.

This species is named for the island on which it was collected. The holotype and paratypes will be placed in the Australian Museum, Sydney, N.S.W.

BIOLOGICAL NOTES: All ecological information available is given under the listing

of the type and paratypes. We cannot account for the fact that the collections had 7 females and no males.

Alpheus balaenodigitus sp. nov.
Fig. 70

HOLOTYPE: 28 mm ovigerous female from Port Walcott, W.A. 20°39′ S; 117°10′E. 8 fms. Coll. Royce on the **Davena,** 3/6/60. (WM 172-65).

ADDITIONAL SPECIMEN: 22 mm female from Darwin, N.T. Collected intertidally from under rocks lying on clean sand. (BAU 72).

DESCRIPTION: Rostrum acute, reaching to end of first antennular article, bearing on margins 6 short setae. Rostral carina rounded, disappearing at posterior margin of eyes. Orbitorostral grooves of moderate depth. Anterior margin of orbital hoods almost straight, only slightly concave at base of rostrum. Visible part of first antennular article and third article subequal, second article 1.6 times as long as third and 2 times as long as wide. Stylocerite reaching to slightly beyond end of first antennular article. Outer margin of scaphocerite concave, squamous portion reaching to end of antennular peduncle, lateral tooth reaching well past. Carpocerite reaching to end of antennular peduncle. Basicerite with small lateral tooth.

Ratio of articles of third maxilliped: 10:3:8.

Large chela 3.5 times as long as broad, fingers occupying distal 0.4. Superior saddle shallow, broad, with proximal and distal shoulders low and rounded; depression on lateral face quadrangular and shallow, merging with the face proximally near *linea impressa;* medial depression shallow, triangular, with apex reaching to about middle of palm. Inferior margin with only a slight constriction opposite superior saddle. Merus 2.5 times as long as broad, bearing a few stiff setae and a small subacute tooth distally on inferionternal margin.

Small chela of female 4.3 times as long as broad with fingers and palm equal. Dactylus nearly conical, bearing on both faces crests of short hairs that almost meet distally on superior margin (sub-balaeniceps). Palm with shallow superior saddle and low rounded shoulders; medial and lateral palmar depressions present but smaller and more indistinct than those of large chela. Inferior margin with slight constriction opposite superior saddle. Palm bearing rounded tooth flanking medial side of dactylar articulation. Medial face of chela with only scattered long setae, lateral face glabrous. Merus 3 times as long as broad, inferointernal margin bearing a small subacute tooth directed distally.

Carpal articles of second legs with ratio 10:10:3:3:6.

Ischium of third leg bearing strong spine. Merus 5.6 times as long as broad, inermous. Carpus 0.6 as long as merus, distal margins slightly projected. Propodus 0.7 as long as merus, bearing on inferior margin 14 spines, more or less in pairs and a pair distally. Dactylus slender, conical, 0.3 as long as propodus.

Telson 2.3 times as long as broad at posterior margin, posterior margin arcuate and projecting. Anterior pair of dorsal spines set well anterior to midline.

DISCUSSION: In the specimen from Darwin the anterior margin of the carapace at the base of the rostrum is more concave. The proximal shoulder of the groove on the superior margin of the large chela is more nearly at right angles to the floor of the groove, not gradually sloping and there is a small but definite inferior shoulder. The tooth on the

Fig. 70 *Alpheus balaenodigitus* sp. nov.
Holotype (female). **a, b.** Anterior region, dorsal and lateral view; **c.** large cheliped, medial face; **d.** large chela, lateral face; **e, f.** small chela, lateral and medial face; **g.** second leg; **h.** third leg; **i.** telson. 22 mm female from BAU 72. **j.** Anterior region, dorsal view; **k.** large cheliped, medial face; **l.** large chela, lateral face. All drawings same scale.

distal end of the inferointernal margin of the merus of the large chela is larger and more acute and the margin bears an articulated spine at about two-thirds the length. The third leg is 5.0 times as long as broad and there are less spines on the propodus.

This species is among the group of species in the Edwardsii Group in which the female bears crests of hairs on the dactylus of the small chela. These include *A. pareuchirus imitatrix* De Man, *A. strenuus strenuus* Dana, *A. s. cremnus subsp. nov.*, *A. heeia* B&B and *A. australiensis sp. nov.* It differs from both *A. s. strenuus* and *A. s. cremnus* by having the proximal shoulder of the superior saddle of the large chela gradually rounded; not at all projected; the plunger on the dactylus of the large chela is long and heavy in the two subspecies while in *A. balaenodigitus* it is low and not distally demarked; finally the orbital margin of the orbitorostral groove in *A. s cremnus* is a sharp ridge while in *A. balaenodigitus* it is gradually rounded. In *A. p. imitatrix* the proximal shoulder of the small chela of the female overhangs the superior groove, but is only low and gradually rounded in this species. It can be distinguished from *A. heeia* by the lack of spines on the inferior margin of the second article of the third maxilliped. Finally it can be separated from *A. australiensis* by the presence of the distal tooth on the inferointernal margin of the meri of both chelipeds and again by the low confluent plunger on the dactylus of the large chela. The profile of the superior margin of the large chela of the holotype resembles *A. euphrosyne euphrosyne* De Man, *A. microrhynchus* De Man and *A. paludicola* Kemp, but the rostrum of this species is better developed than in any of those species and in none of those does the female bear a crest of hair on the dactylus of the small chela.

It is unfortunate that we lack the male of this species, but the female appears sufficiently distinct for us to consider it a new species. We note the differences in the large chelae of the holotype and the specimen from Darwin and suggest that they may eventually be found to be of separate genetic stocks, and for that reason we are not designating the second specimen as a paratype. Yet with but two specimens we are loath at this time to give them separate designations.

The name is taken from *balaena*, Latin for whale, and refers to the sub-balaeniceps condition of the dactylus of the small chela, a rare condition for a female in this genus.

The holotype will be placed in the Western Australian Museum and the additional specimen will be deposited in the Australian Museum.

Alpheus strenuus strenuus Dana
Fig. 71

Alpheus strenuus Dana, 1852:543, pl. 34, fig. 4. Coutière, 1905a:913, fig. 53. Pearson, 1911:185, pl. 7, fig. 6. Gravely, 1930:79, pl. 1, figs. 6a, b. Banner and Banner, 1966a:191, fig. 20; 1966b:140, fig. 53.

Alpheus strenuus var. angulatus Coutière, 1905a:914.

Alpheus doris White, 1847:75 *(nomen nudum)*.

Previous Australian records:
White, loc. cit. Torres Straits (as *A. doris*).
Heller, 1865:108. Sydney, N.S.W. (as *A. avarus*).
Haswell, 1882b:188. Torres Straits.
Ortmann, 1890:475. Rockhampton, Qld.
Ortmann, 1894:14. Thursday Island.
Pope, 1949:326. Discussion of sound production (as *Crangon strenuus*).

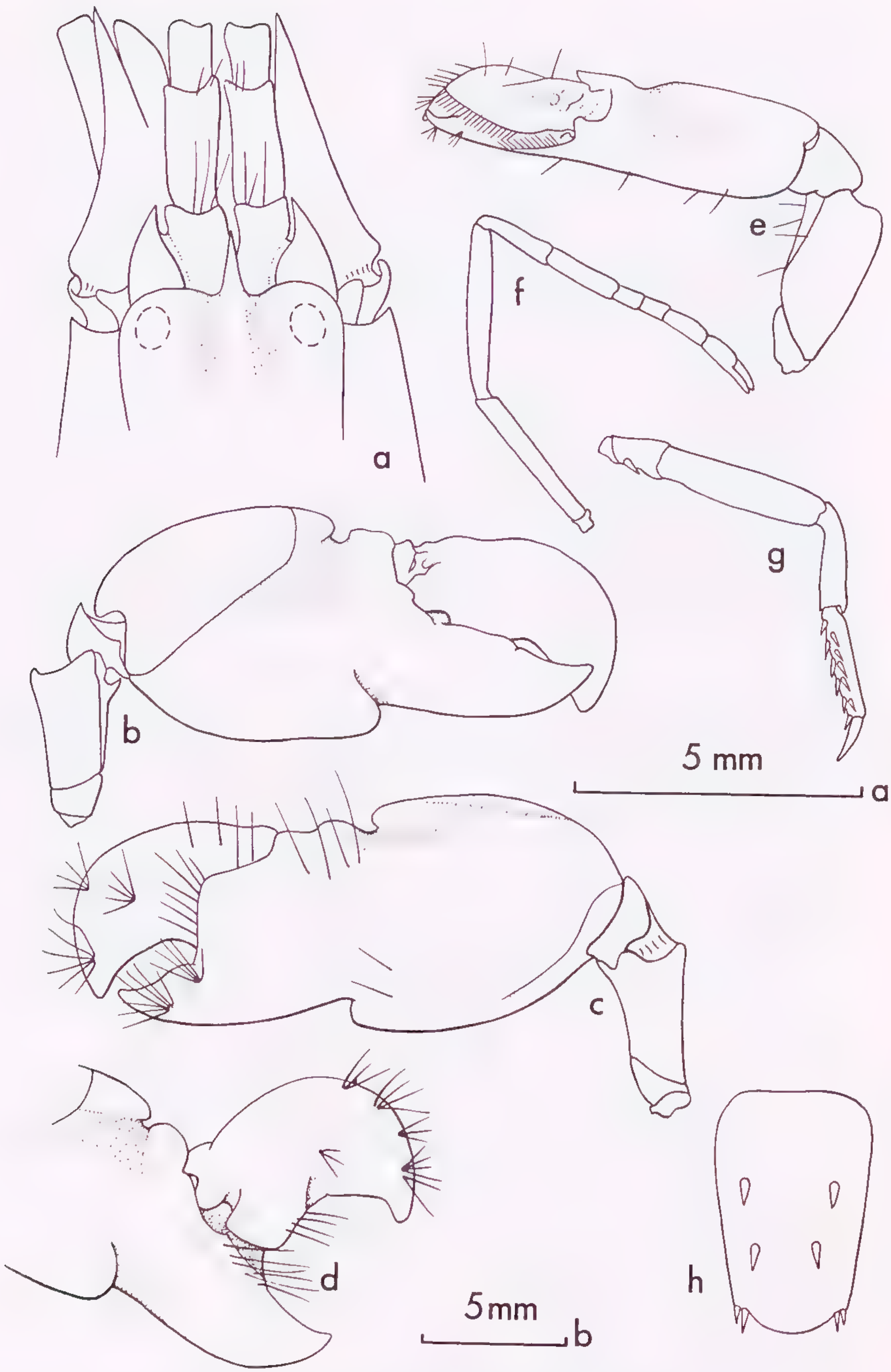

Fig. 71 *Alpheus strenuus strenuus* Dana
40 mm male from BAU 23. **a.** Anterior region, dorsal view; **b, c.** cheliped, lateral and medial face; **d.** fingers of large chela, lateral face; **e.** small cheliped, lateral face; **f.** second leg; **g.** third leg; **h.** telson. b, c, d, e, f, g scale a; a, h scale b.

Dakin, 1960:178. Discussion of sound production.
McNeill, 1968:15. North Qld.

SPECIMENS EXAMINED: 1 specimen from AH 1; 1, AH 2; 2, AM 4 (AM P. 27512); 1, AM 19 (AM P. 27801); 1, AM 104 (AM P. 27318); 1, AM 107 (AM P. 27518); 1, AM 108 (AM P. 28154); 2, AM 167 (AM P. 27465); 1, AM 218 (AM P. 27464); 2, AM 230 (AM P. 28105); 1, AM 249 (AM P. 27319); 2, AM 274 (AM P. 27804); 1, AM 276 (AM P. 27406); 1, AM 293 (AM P. 27805); 6, AM 298 (AM P. 27768); 1, AM 308 (AM P. 27806); 3, AM 309 (AM P. 27453); 2, AM 317 (AM P. 27350); 1, AM 318 (AM P. 27351); 1, AM 319 (AM P. 27352); 1, AM 321 (AM P. 27353); 5, AM 322 (AM P. 27354); 1, AM P. 2289; 1, AM P. 4313; 3, AM P. 5572; 2, AM P. 5610; 2, AM P. 6786; 1, AM P. 7187; 1, AM P. 7240; 1, AM P. 7421; 11, AM P. 7443; 2, AM P. 7523; 2, AM P. 7982; 1, AM P. 8565; 1, AM P. 10401; 2, AM P. 10979; 1, AM P. 11408; 1, AM P. 13549; 4, AM P. 14960; 1, AM P. 27766; 3, AM P. 28155; 16, BAU 12; 1, BAU 23; 4, BAU 27; 1, BAU 29; 7, BAU 46; 12, BAU 51; 1, BAU 52; 3, BAU 54; 11 BAU 72; 3, JB 1; 2, JC 24; 1, JG 22-73; 3, QM W 1000; 3, QM W 2236; 3, UQ 23; 1, US 123589; 1, US 123591; 1, WM 245-65; 1, WM 285-65; 7, WM 292-65; 1, WM 8973.

DIAGNOSIS: Rostrum acute, slender, over 2 times as long as broad at the base, reaching into distal half of first antennular article. Orbital hoods slightly inflated; orbitorostral grooves shallow and gradually confluent with hoods and rounded rostral carina, extending posteriorly only slightly behind pigmented portion of eyes. Antennular peduncle with second article varying from 1.6 to 2.5 times as long as broad and almost 1.5 times as long as visible part of first antennular article; third article shorter than visible part of first. Stylocerite acute, reaching to end of first article of antennular peduncle. Lateral tooth of scaphocerite a little longer than antennules, squamous portion of normal width, a little shorter than lateral tooth. Carpocerite reaching to end of antennular peduncle. Basicerite with acute slender tooth.

Large chela 2.3 times as long as broad, fingers occupying distal 0.4, and when closed approaching breadth of palm. Superior saddle deep, moderately broad. Proximal shoulder heavy, rounded and overhanging saddle slightly. Distal shoulder also heavy, gradually rounded. Lateral palmar depression well defined, quadrangular, reaching to *linea impressa*. Medial palmar depression triangular reaching to proximal half of palm. Inferior shoulder strong, rounded, and projecting slightly. Inferolateral depression "V"-shaped; inferomedial depression almost quadrangular and with proximal apex continuing longitudinally as a narrow but pronounced groove that terminates near carpal articulation. Dactylus with plunger long. Merus 2.4 times as long as broad, superior margin rounded, inferointernal margin bearing distally an acute tooth.

Small chela of both sexes, in both large and small specimens, with balaeniceps dactylus. Chela varying from 3.3-4.3 times as long as broad with fingers occupying distal 0.4. Palm bearing slight rounded superior saddle. On large specimens the groove continues into a slight, poorly defined depression on lateral face. No trace of inferior shoulder. Superior surface of dactylus broadened with carinate ridge extending from articulation and fading near middle of broadened area. Broadened area demarked by setiferous crests typical of balaeniceps development; tip narrow and hooked, crossing tip of pollex when closed. Merus 2.3 times as long as broad; superior margin rounded, inferointernal margin bearing a small acute tooth distally.

Carpal articles of second leg with ratio of: 10:10:3:3:6.

Ischium of third leg armed with spine. Merus inermous, 4.3 times as long as broad. Carpus 0.5 as long as merus with superodistal margin projected into a tooth. Propodus 0.7 as long as merus and bearing on its inferior margin 10 spines, roughly paired. Superior

margin bearing many long fine setae. Dactylus simple, triangular in cross section, 0.4 as long as propodus.

Telson 2 times as long as posterior margin is broad, anterior pair of dorsal spines placed slightly anterior to middle.

DISCUSSION: Dana's holotype for this species was collected from Tongatabu, Tonga and was presumed to be lost, probably with W. Stimpson's collections in the Chicago, Ill. fire of 1871. With that in mind, in 1954 when the senior author visited the type locality, he collected a series of specimens from which we selected one to be a neotype. Before the collection could be published upon most of the specimens of the neotypic series and the figures of the neotype-to-be were destroyed by fire. However, the description and the comparative studies we had made did survive and we published them, along with new drawings of a smaller specimen from Tongatabu that also came through the fire (1966a:181). No neotype was designated.

This year (1978) we discovered in the Museum of Comparative Zoology at Harvard University a specimen from the U.S. Exploring Expedition collections that was labelled as "1469 TYPE *Alpheus strennus* Dana. Tongatabu. U.S. Exploring Expedition." (A later label said the same thing except it was to "*Crangon strennus* (Dana)"). However, this specimen, a male, is but 25 mm long and Dana specified his type to be 1¾ inches (about 44 mm) long, so this specimen must be from his paratypic series. Moreover, of all the walking legs it has only one fourth and both fifth legs remaining, so it cannot be used to establish the characteristics of the species. We have compared what remains of it with our 1966 description and our specimens and find no apparent differences. Therefore our description of the topotype can be taken as a fair representation of the form that Dana had described.

In our 1966 paper we discussed the extent of variation we had observed in our specimens together with its differentiation from related species. We found variation in the specimens from the Central Pacific in the porportions of some of the appendages, especially in the antennular peduncles, the large and small chela (those of the more mature specimens being heavier), and the third legs. However, the form was quite constant. We regard the balaeniceps development of the small chela in the females as an excellent characteristic for the separation of this species from most of the other species of the Edwardsii Group.

The variation we found in the Australian specimens parallels that which we found in those from the Central Pacific, with one exception. While we found the sculpturing of the palm of the small chela to be variable in both males and females from the Central Pacific, in no case did it reach the marked sculpturing we found in some, but not all, of the Australian specimens. Even greater sculpturing is found in the new subspecies *A. s. cremnus*. We regard the sculpturing of the palm of this chela as too variable to be used as a criterion for specific or subspecific separation. It should be noted in passing that the small chela figured by Tiwari from Vietnam (1963, fig. 29e) approaches the condition we found in many specimens from Australia. We found (1966a:185) the characteristics used by Coutière for the separation of *A. s. angulatus* from the Maldives and Laccadives to be within the normal variation we described. We accepted *A. s. galapagensis* of Sivertsen (1934:3) as distinct. Inasmuch as he depicted the small chela of the male with a simple, conical dactylus, we now suggest it may be a separate species.

BIOLOGICAL NOTES: This species is most commonly collected under rocks on sandy beaches in the lower portion of the intertidal zone. It has been our observation from other collecting sites in the Indo-Pacific area that this species does not occur where the substrate carries a great deal of mud. For further discussion see *A. s. cremnus*. One of

the specimens (BAU 72) was found in a hole in the coral directly underneath a brittle star *Macrophiothrix longipeda* (Lamark, 1816). (Ophiuroid identified by Dr Dennis Devaney of the Bishop Museum, Honolulu, Hawaii). We have also often found the "fire worm" *Eurythoe* occupying the burrows of this shrimp.

The colour is apparently variable. For this subspecies we have colour notes supplied by Yaldwyn for specimens from One Tree Island (AM 317) "Green yellow with some white markings on carapace and abdomen"; (AM 318) "Hands mottled with large areas of olive green and white"; (AM 319) "Hands orange with irregular patches of dark grey, eggs orange". Gravely (1930:79) reports on a specimen from the Gulf of Manaar: "The colour of the living animal is greenish brown, often either mottled or striped more or less distinctly with white. When stripes are present they are usually longitudinal, but may be transverse". Our specimens ranged in size up to 64 mm in length, but Coutière (1905a:913) reports specimens as large as 95 mm.

AUSTRALIAN DISTRIBUTION: Specimens in western Australia were collected between Dampier and Cockatoo Island; in the north they came from Darwin, Gulf of Carpentaria and the Torres Straits; the majority of specimens came from eastern Australia and were collected between Cooktown, Qld. and Sydney, N.S.W. (See also discussion under *A. s. cremnus* subspec. nov. following).

GENERAL DISTRIBUTION: This subspecies has been collected all through the Indo-Pacific from the Red Sea to the Society Islands and possibly to the Galapagos Islands (Schmitt 1939:26, as *Crangon strenuus*), but it does not occur in Hawaii.

Alpheus strenuus cremnus subspec. nov.

Fig. 72

HOLOTYPE: 50 mm male collected on the intertidal rock platform at Minnie Waters, near Grafton, N.S.W. in Feb. 1965 by J. C. Yaldwyn. AM 12 (AM P. 27194).

ALLOTYPE: 60 mm female collected with the holotype. (Presumed to be a cohabiting pair.) (AM P. 27195).

PARATYPES: 2 specimens from AM 14 (AM P. 27196); 1, AM 37 (AM P. 27197); 1, AM 41 (AM P. 27265); 1, AM 77 (AM P. 27206); 1, AM 84 (AM P. 27244); 1, AM 132 (AM P. 27245); 2, AM 152 (AM P. 27198); 1, AM 212 (AM P. 27207); 1, AM 344 (AM P. 27208); 1, AM 345 (AM P. 27246); 1, AM 349 (AM P. 27200); 3, AM 383 (AM P. 27247); 1, AM 385 (AM P. 27199); 1, AM 399 (AM P. 27209); 4, AM 422 (AM P. 27210); 2, AM 441 (AM P. 27211); 2, AM 445 (AM P. 27226); 3, AM P. 4950; 1, AM P. 6914; 3, WM 89-65; 3, WM 131-65; 9, WM 185-65; 5, WM 221-65; 11, WM 278-65; 2, WM 299-65.

DIAGNOSIS: Rostrum narrow, acute, with tip reaching almost to or slightly beyond end of first antennular article; rostral carina dorsally rounded but laterally abrupt, reaching well behind pigmented portions of eyes. Orbitorostral grooves pronounced and broad, posteriorly "U"-shaped when seen dorsally with margin anteriorly divergent. Orbital hoods not markedly inflated, but well demarked from grooves by sharp ridge that posterior to eyes may overhang an abrupt and concave lateral wall of groove; anteriorly wall of groove abrupt but not concave and ridge not overhanging; ridge of orbital hoods at times lying dorsal to medial portion of pigmented facets of eyes. Frontal margins of orbital hoods hemispherical. Second antennular article 1.8 times as long as broad and 1.7 times longer than visible part of first antennular article; third article subequal to visible part of first. Stylocerite acute, reaching end of first antennular article. Scaphocerite with lateral tooth strong, reaching well past end of antennular peduncle; squamous portion as normal, reaching to end of antennular peduncle. Carpocerite a little longer than lateral

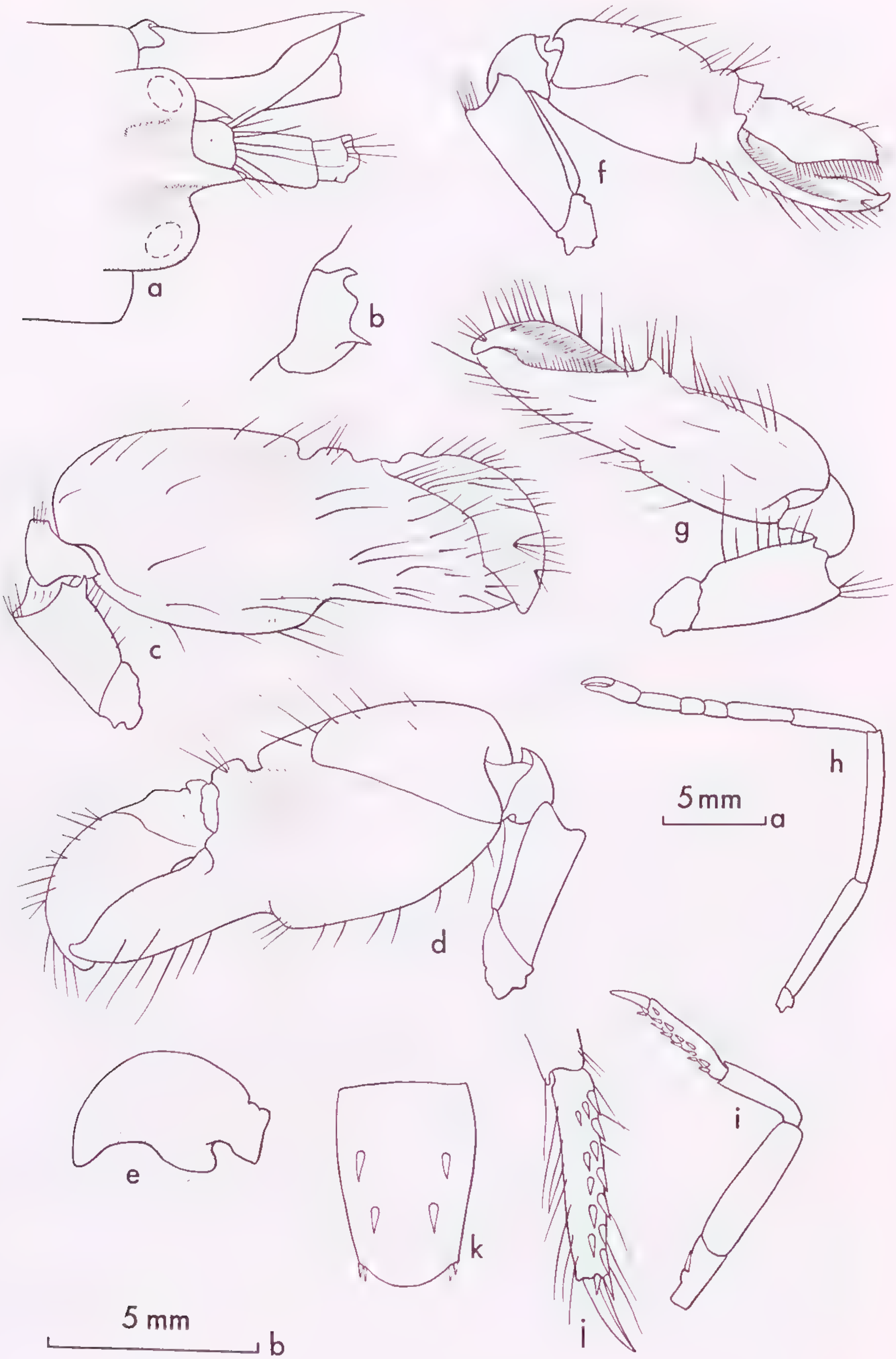

Fig. 72 *Alpheus strenuus cremnus* subspec. nov.
Holotype (male). **a.** Anterior region, dorsal view; **b.** basicerite, lateral view; **c, d, e.** large cheliped, medial and lateral face and dactylus; **f, g.** small cheliped, lateral and medial face; **h.** second leg; **i, j.** third leg and enlarged propodus and dactylus; **k.** telson. b, c, d, e, f, g, h, i scale a; a, j, k scale b.

spine of scaphocerite. Basicerite bearing acute slender tooth.

Ratio of articles of third maxilliped: 10:3:7.

Large chela compressed, massive, 2.5 times as long as broad with fingers occupying approximately the distal third. Superior saddle deep and quite narrow; proximal shoulder slightly overhanging saddle, distal shoulder prominent and initially abrupt. Lateral palmar depression well defined, quadrangular, reaching proximally to *linea impressa*. Medial palmar depression a narrow triangle with apex reaching to proximal third of chela. Inferior shoulder heavy and rounded; inferior notch prominent. Inferolateral depression continued up face of palm 0.2 total width, disappearing into pollex distally. Inferomedial depression small, but continuing proximally as a narrow longitudinal groove almost reaching to articulation at proximal end of chela. Medial face of chela sparsely hirsute, lateral face glabrous. Plunger of dactylus only moderately developed. Merus 1.6 times as long as broad; and inferoexternal and superior margins rounded distally; inferointernal margin with acute tooth distally.

Small chela of both male and female of balaeniceps form. Cheliped 3.4 times as long as broad; fingers a little shorter than palm. Superior and inferior margin of palm bearing shoulders, grooves and depressions similar to palm of large chela but not as pronounced. Articulation of dactylus flanked medially by a small obtuse projection. Adhesive plaque of dactylus borne on flattened triangular areas, laterally rounded, but demarked medially by rounded ridge that continues distally, disappearing slightly proximal to point of union of balaeniceps setiferous crests; ridge proximally bearing scattered setae. Medial face of entire chela bearing long forward-sweeping hairs, more distally than proximally; lateral face glabrous. Merus similar to that of large chela, 2.7 times as long as wide.

Second leg with ratio of carpal articles: 10:8:2:2:5.

Ischium of third leg bearing tooth. Merus 3.8 times as long as broad, inermous; carpus 0.6 as long as merus, distosuperior and distoinferior margins slightly projected. Propodus 0.7 as long as merus, inner face bearing 14 spines, roughly paired. Dactylus triangluar in section, simple, 0.4 as long as propodus.

Telson 1.8 times as long as posterior margin is broad; posterolateral spines small, spines on dorsal surface of telson prominent.

DISCUSSION: This subspecies is identical to the nominate subspecies except in two morphological characteristics and apparently in its ecology. The most pronounced and consistent difference in the structure in is in the orbital grooves. In *A. s. strenuus* they are shallow and rounded, with the margins confluent with curvature of rostrum and the orbital hoods; they extend only slightly posterior to the pigmented portions of the eyes. In *A. s. cremnus,* they are deeper, broader and extend further posteriorly; medially the sides of the rostrum are more abrupt, and laterally, posterior to the pigmented portion of the eyes, a ridge of the orbital hood overhangs the concave margin of the groove; even at the posterior end the grooves are firmly demarked from the carapace.

The second morphological characteristic is in the sculpturing of the palm and the ridge of the dactylus of the small chela of both males and females. As remarked under *A. s. strenuus,* the degree of sculpturing of the palm of the small chela was found to be variable but usually slight in the Central Pacific specimens; those from Australia are also variable but usually have a greater degree of sculpturing. However, this difference between the Australian and the Central Pacific specimens is not great enough or constant enough to warrant in our opinion the designation of the Australian form as a separate subspecies. On the other hand the difference in sculpturing of the small chelae between *A. s. strenuus* and *A. s. cremnus* is marked and almost always present, with that of *A. s.*

cremnus much more like that of the large chela — contrast figs. 71e and 72f. In only a few specimens of *A. s. strenuus,* as determined by the nature of the orbital grooves, did the sculpturing approach the extreme conditions characteristic of this subspecies. As these occurred in the waters of New South Wales where evidently the two subspecies coexist, they may be hybrids.

We believe there may be an ecological separation between the two subspecies, as well, but this cannot be proven by the collection data available with the two subspecies. The two forms overlap geographically. However *A. s. strenuus* occurs definitely on coral reefs and coral cays, and along more continental shores, but apparently in clean sand and cleaner waters, while *A. s. cremnus* may occur more commonly in muddy and estuarine environments, such as Moreton Bay, the mouth of the Clarence River, near the mouth of Tuggerah Lake, etc. Yet both subspecies have been collected from Long Reef, Collaroy, on the ocean coast of north Sydney. If the two forms we are here calling subspecies are indeed found to overlap ecologically, then *A. s. cremnus* should be considered to be a separate species.

The name is derived from the Greek word *cremnos,* which means, in part, an overhanging wall or bank and refers to the lateral margins of the orbitorostral grooves. The holotype and allotype as well as some paratypes will be deposited at the Australian Museum in Sydney, N.S.W. Paratypes will be placed in the Western Australian Museum, Perth, W.A.

BIOLOGICAL NOTES: The evidently cohabiting pair we selected for the holotype and allotype had the female larger, but in other pairs this size relationship did not hold.

Healy and Yaldwyn, (1970, pl. 18) published a colour picture of a specimen from Long Reef, N.S.W. (AM 399); it shows an overall red cast with the cephalic and thoracic appendages definitely light red. The carapace is a brownish-red and the abdomen with transverse bands separated by pinkish-white, brown and white irregular bands on caudal fan. Yaldwyn described the holotype and allotype as "purplish-red with transverse abdominal bands of the same colour". He described a similar coloration for four other specimens. However, one specimen from the Clarence River was noted by Cameron, the collector, as "striped with olive green and white, brick red hands." (AM 132).

AUSTRALIAN DISTRIBUTION: Most of the specimens came from near Sydney and on the other parts of the coast of New South Wales; however, collections of it were made near Hopetoun (near Albany) from Cape Leveque and Yampi Sound, W.A. and from Darwin, N.T., the Gulf of Carpentaria and Moreton Bay, Qld.

Alpheus euphrosyne euphrosyne De Man
Fig. 73

Alpheus euphrosyne De Man, 1897:745, fig. 64 a-d; 1898b:317, pl. 4, fig. 2. Banner and Banner, 1966b:130, fig. 49.
Alpheus eurydactylus De Man, 1920:109; 1924:48, fig. 17.

SPECIMENS EXAMINED: 4 specimens from AM 81 (AM P. 28127); 2, AM 96 (AM P. 28128); 1, AM 162 (AM P. 28129); 1, AM 202 (AM P. 28130); 1, AM 279 (AM P. 28131); 1, AM 310 (AM P. 28132); 1, QM W 2248.

DIAGNOSIS: Rostrum triangular, short and variable in length, not reaching further than middle of visible part of first antennular article. Rostral carina low, rounded, extending past posterior end of orbital hoods; orbitorostral grooves shallow, at times non-existent. Second antennular article almost twice as long as broad and 1.5 times as

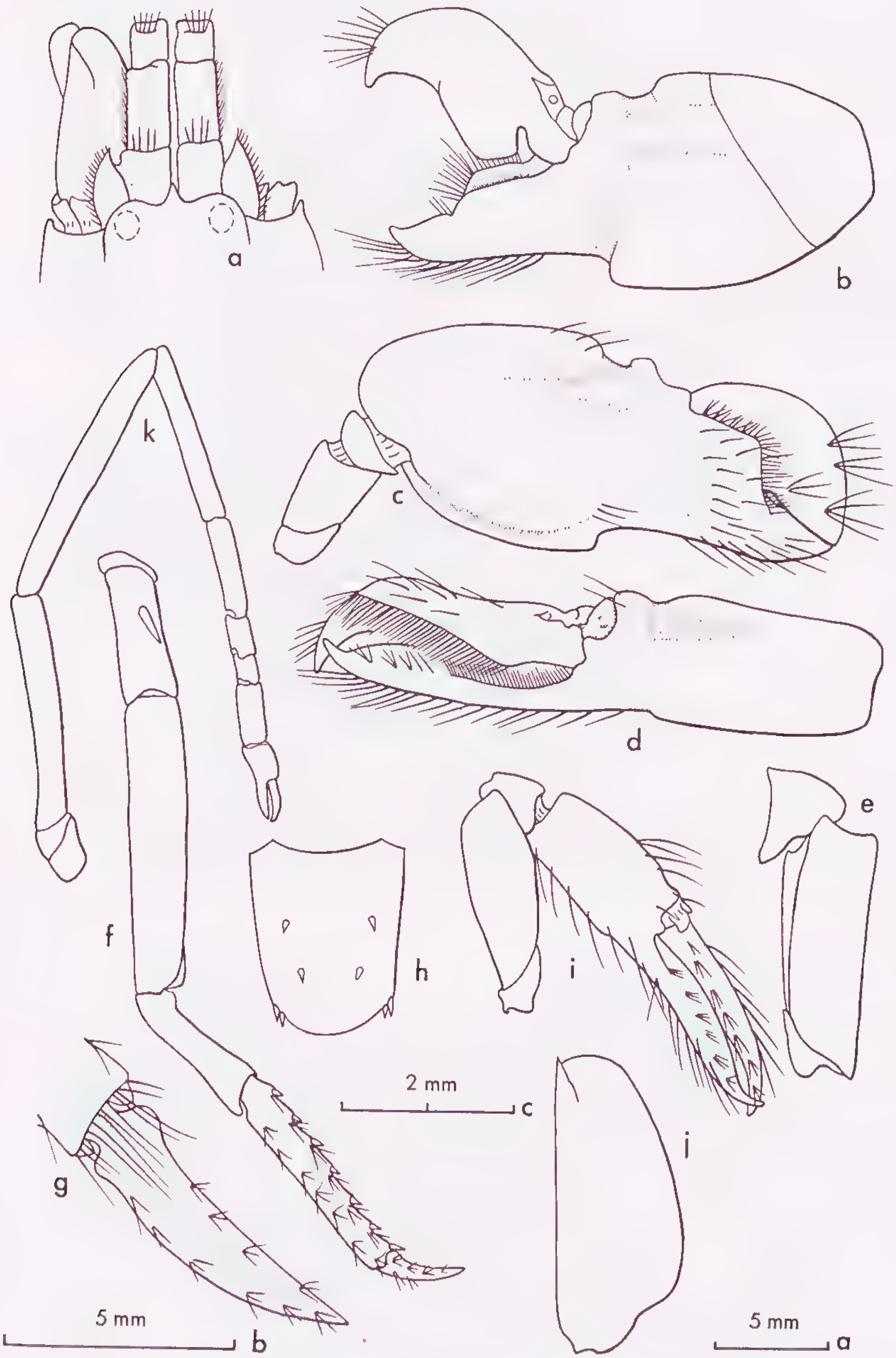

Fig. 73 *Alpheus euphrosyne euphrosyne* De Man
78 mm male from AM 162. **a.** Anterior region, dorsal view; **b.** large chela, lateral face; **c.** large cheliped, medial face; **d, e.** small chela and merus, lateral face; **f, g.** third leg and enlarged dactylus, superomedial face (spatulate side not shown); **h.** telson. 55 mm female from AM 96. **i.** Small cheliped, lateral face; **j.** scaphocerite. 43 mm female from AM 2; **k.** Second leg. a, b, c, d, e, f, h, i scale a; j, k scale b; g scale c.

long as visible part of first; third article 0.7 length of first; lateral margins bearing many short setiferous bristles. Stylocerite broad, tip acute, and reaching to end of first antennular article, with short stiff setiferous bristles on lateral margins. Scaphocerite with outer margins slightly convex, squamous portion broad, usually equal to lateral tooth, but sometimes longer. Carpocerite as long as antennular peduncle. Basicerite usually unarmed.

Large chela heavy, 2.3 times as long as broad. Superior saddle broad and shallow with proximal and distal shoulders gently rounded; medial palmar depression shallow and triangular with apex reaching to middle of palm, lateral palmar depression a little deeper, quadrangular and reaching to *linea impressa*. Inferior shoulder at right angles to margin, rounded; inferior notch continued on lateral face as slight triangular depression, but not appearing on medial face. Inferior margin carrying on medial side a longitudinal groove arising in proximal third of palm and extending almost to inferior shoulder where it turns upward. Plunger well developed. Merus only slightly longer than broad, unarmed.

Small chela sexually dimorphic with male bearing typical balaeniceps dactylus. Male chela 4.5 times as long as broad, fingers equal to palm in length. Sculpturing similar to that of large chela but much less pronounced. Crest of hairs on margins of dactylus cross superior surface proximal to curved acute tip; flattened area conspicuously triangular. Pollex bearing fringe of setae proximally. Merus 3 times as long as broad, unarmed. Female chela 5.3 times as long as wide, fingers 1.2 times length of palm. Palm with slight traces of superior saddle and inferior shoulder. Merus similar to that of male.

Second leg with ratio of carpal articles: 10:(4-8):2:2:3.

Ischium of third leg often without spine. Merus inermous, 5 times as long as broad. Carpus 0.5 as long as merus with superior margin projecting but rounded. Propodus 0.8 as long as merus and bearing 7 stout spines on inferior margin and a pair distally; propodus also bearing tufts of short stiff setae in rows on either face near row of spines and a third row near superior margin on medial face. Dactylus 0.4 as long as propodus, spatulate and slightly curved; also bearing tufts of setae similar to propodus near superior and inferior margins.

Telson broad, 1.3 times as broad anteriorly as posteriorly and 1.4 times as long as posterior margin is broad; lateral margins slightly convex, posterior margins strongly convex, superior and posterolateral spines small.

DISCUSSION: De Man had only 2 females from the Java Sea upon which to base his original description. Later (1898b:317) with a smaller specimen from Bangkok he was able to describe and figure the small chela of the male. He reported on a large specimen from Postillon Is. (Indonesia) (1911:413), but unfortunately the specimen was mutilated. We examined this specimen at the Zoologisch Museum in Amsterdam and while it does lack the anterior thoracic legs the parts remaining are certainly typical for the species. The only other report was ours based on 127 specimens from Thailand, largely from mangrove swamps (1966b:130) from which we established the extent of variation. These variations included the proportions of the articles of the antennular peduncle, the presence or absence of the lateral tooth of the basicerite, the length of the lateral spine to the blade of the scaphocerite, the proportions and to some degree the sculpturing of the large and small chela (the absence of sculpturing in the male small chela did not always appear to be associated with smaller size), the occasional presence of a small inferointernal spine on the merus of the large cheliped, the relative proportions of the first two carpal articles of the second legs, the presence or absence of a spine on the ischium, and the proportions of the meri of the third legs. The few Australian specimens available fall well within the range reported from Thailand.

In view of the variation we noted in our specimens from Thailand, we wish to review the status of *A. eurydactylus* which De Man described from an unspecified location and habitat on Java. In 1924 he redescribed the species in greater detail and expressed doubts about its separation from *A. euphrosyne*. He finally decided to let the species stand until more specimens of *A. euphrosyne* were known. The differences he reported were in the size of the orbitorostral groove, and in the proportions of some of the appendages. In our examination of his holotype and allotype at the Zoologisch Museum in Amsterdam we found the differences between this nominal species and *A. euphrosyne euphrosyne* were easily bridged by the variation noted in the Thai specimens. Therefore we are placing the name *A. eurydactylus* in synonymy.

We are also reducing *A. richardsoni* Yaldwyn and *A. langi* (Schmitt) to subspecific rank under this species; these will be discussed under *A. e. richardsoni* following. This has required the nominate form to bear a subspecific designation.

BIOLOGICAL NOTES: The species appears to be adapted for muddy estuarine conditions. The Australian specimens were all found in such conditions, some being specifically reported from burrows of the crab *Sesarma* sp. which were dug in river banks. In Thailand the species was the only species found in mangrove swamps, but some were also found under rocks on sandy-muddy beaches where there was a fresh water leakage and in the shrimp trawls from the bottom of a shallow brackish lake (Lake Songkla).

AUSTRALIAN DISTRIBUTION: The specimens in the collections ranged from Townsville to Princess Charlotte Bay, Queensland; we would suspect that the species will also be found elsewhere under similar conditions along the tropical coasts of Australia.

GENERAL DISTRIBUTION: Indonesia and Thailand.

Alpheus euphrosyne richardsoni Yaldwyn, new combination

Fig. 74

Alpheus sp. of the Edwardsii Group, Richardson and Yaldwyn, 1958:37, fig. 35.

Alpheus richardsoni Yaldwyn, 1971:88.

Alpheus euphrosyne Hutching and Recher, 1974:106.

SPECIMENSEXAMINED: 6 specimens from AM 51 (AM P. 27879); 1, AM 87 (AM P. 27881); 4, AM 103 (AM P. 27882); 4, AM 127 (AM P. 27870); 2, AM 195 (AM P. 27860); 1, AM 227 (AM P. 28156); 2, AM 241 (AM P. 27871); 2, AM 386 (AM P. 28157); 1, AM 463 (AM P. 27857); 1, AM 464 (AM P. 27858); 1, AM 466 (AM P. 27859); 8, AM G. 6139; 1, AM P. 1441; 2, AM P. 2021; 3, AM P. 2022; 1, AM P. 2152; 1, AM P. 2347; 1, AM P. 3581; 2, AM P. 4497; 12, AM P. 4601; 3, AM P. 4602; 3, AM P. 4681; 1, AM P. 4839; 2, AM P. 5137; 1, AM P. 5356; 1, AM P. 6449; 2, AM P. 6468; 2, AM P. 6682; 3, AM P. 6710; 2, AM P. 7164; 2, AM P. 7463; 3, AM P. 7476; 6, AM P. 9068; 3, AM P. 12952; 4, AM P. 13558; 2, AM P. 13566; 4, AM P. 13576; 3, AM P. 13579; 4, AM P. 17923; 1, AM P. 19636; 4, BAU 5; 5, BAU 21; 7, BAU 59; 16, BAU 60; 4, BAU 61, 1 specimen each from CS 46, 47, 48, 49; 1, MM 178; 4, QM W 2241; 8, QM W 2242; 1, QM W 2243; 1, QM W 2244; 2, QM W 2245; 1, QM W 2247; 2, TM G 1348; 1, TM G 1349; 10, TM G 1359; 1, TM 12877/G51; 1, UQ 3; 1, UQ 9; 1, US 106164; 1, US 106165; 10, US 123603; 3, VM 14; 5, VM 15; 1, VM 27; 47, VM 34; 1, VM 36; 1, VM 935; 1, VM 956; 1, VM 962; 2, WM 294-65; 1, WM 295-65; 34, WM 10229; 27, WM 10199/10208 and 10229-34; 4, WM 10274; 7, WM 11664; 1, WM 11788; 1, WM 15057; 2, WM 15108/9; 2, WM 93/94-96; 2, WM 403/5-38; 6, WM 449/54-32; 1, WM 759-30; 1, WM 120-37; 1, WM 169-37; 1, WM 338-39; 1, WM 497-39; 1, WM 605-39; 2, WM 44-49; 1, WM 270-52; 6, WM 449/54-32.

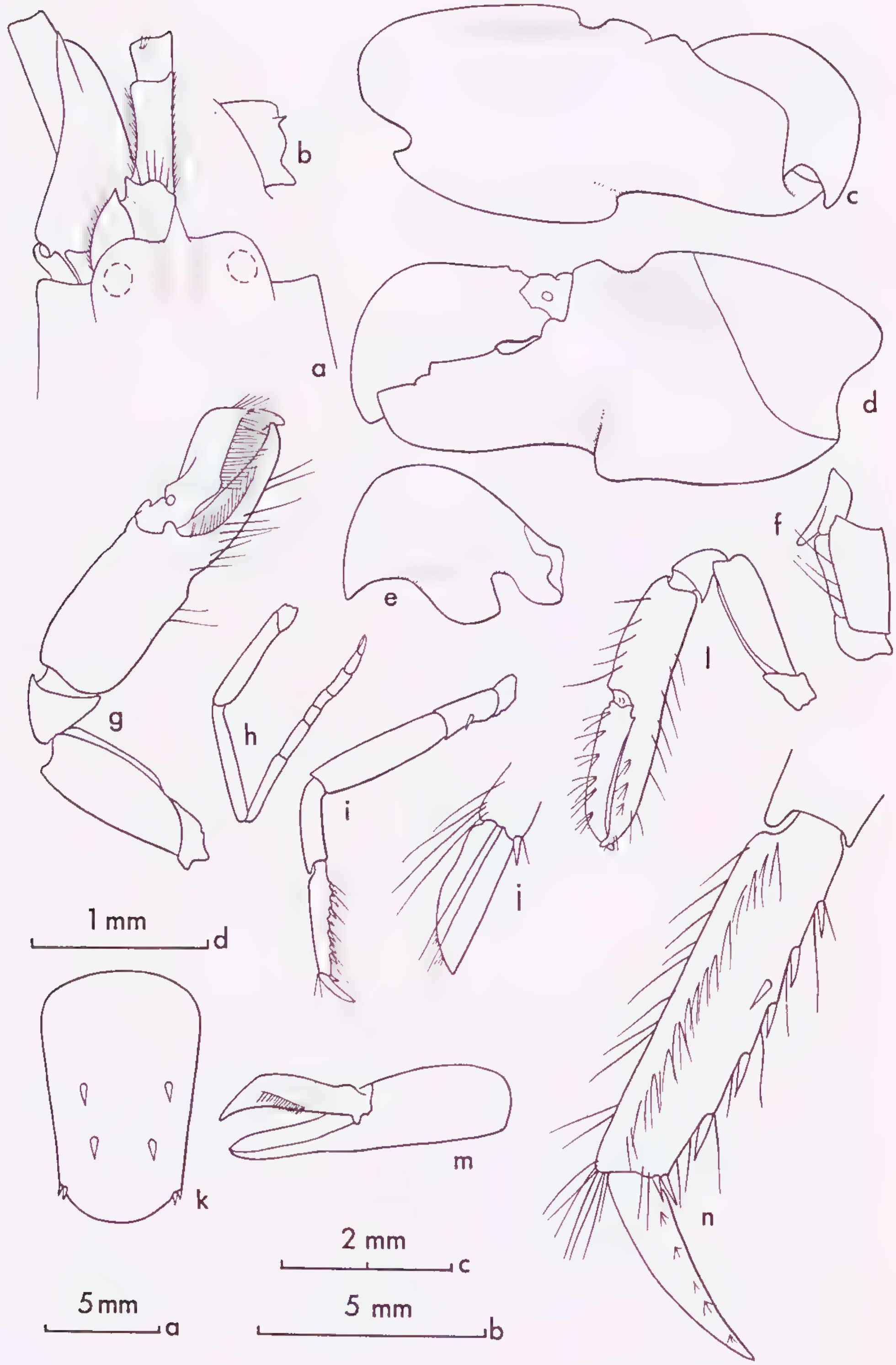

Fig. 74 *Alpheus euphrosyne richardsoni* Yaldwyn
45 mm male from AM P. 4497. **a.** Anterior region, dorsal view; **b.** basicerite, lateral view; **c.** large chela, medial face; **d, e.** large chela and dactylus, lateral face; **f.** merus large chela, lateral face; **g.** small cheliped, lateral face; **h.** second leg; **i, j.** third leg and dactylus; **k.** telson. 48 mm female from AM P. 4495; **l.** Small cheliped, lateral face. 30 mm male from AM P. 2021. **m.** Small chela with minimal balaeniceps development, lateral face. 45 mm male from AM 350. **n.** Enlargement of distal region of third leg. c, d, e, f, g, h, i, l scale a; a, k, m scale b; n, b, scale c; j, scale d.

TABLE 5
Separation of three subspecies of *Alpheus euphrosyne*

	A. e. euphrosyne	*A. e. richardsoni*	*A. e. langi*
1. Orbitorostral margin	Markedly concave	Slightly concave	Slightly concave
2. Scaphocerite	Squamous portion broad, usually longer than lateral tooth, lateral margin straight to convex	Squamous portion only moderately broad, always shorter than lateral tooth, lateral margin slightly concave	Squamous portion usually broad, from longer to slightly shorter than lateral tooth, lateral margin straight
3. Basicerite	Rarely with tooth	Always with tooth	Always with tooth
4. Sculpturing of palm, small chela of males	Usually with strong superior saddle and inferior shoulder	Superior saddle obsolete; inferior shoulder of minimal development	Superior saddle moderate; inferior shoulder lacking
5. Ecology and distribution	Tropical, in muddy estuaries and in mangrove swamps, Indonesia, Thailand and Northern Queensland	Temperate, in muddy estuaries and in mangrove swamps; New Zealand and southern waters of Australia (with one possible exception)	Tropical, in muddy estuaries and in mangrove swamps; mouth of Congo

DIAGNOSIS: Rostrum acute, triangular, reaching past middle of visible part of first antennular article. Rostral carina slight, rounded, reaching to slightly past base of orbits; orbitorstral grooves minimal. Orbitorostral margin at most slightly concave. Ratio of antennular articles beginning with visible part of first article: 10:16:9, second article slighlty more than 2 times as long as broad. Outer margins of antennular articles armed with short setiferous bristles. Stylocerite acute, reaching to last quarter of visible part of first antennular article, outer margins armed with short setiferous bristles. Outer margin of scaphocerite concave, lateral tooth longer than squamous portion which is moderately wide and reaches just beyond antennular peduncles. Carpocerite reaching almost length of third antennular article past that article.

Large chela 2.2 times as long as broad with fingers occupying the distal 0.4. Superior saddle deep, broadly "U"-shaped with both shoulders gradually rounded. Lateral palmar depression well defined, quadrangular, reaching to *linea impressa*. Medial palmar depression well defined, roughly triangular with apex reaching to proximal quarter of palm. Inferior shoulder heavy, lying at right angles to palm. Inferior notch continues into lateral face as a faint triangular depression, into medial face as small triangular depression extending proximally. Plunger of dactylus well developed and heavy. Merus 2.2 times as long as wide, with superior and inferointernal margins extended distally, but without teeth; inferointernal margin bearing a few long hairs.

Small chela sexually dimorphic. Male chela almost 3 times as long and broad with full balaeniceps dactylus. Palm with vestigial superior saddle but relatively heavy inferior shoulder and notch; face of palm without sculpture. Merus 2.7 times as long as broad, unarmed. Small chela of female almost 4 times as long as broad, palm without trace of sculpture, fingers nearly cylindrical with slight knife edge on oppositive faces.

Ratio of carpal articles of second leg: 10:6:2:2:3.

Ischium of third leg usually bearing short spine. Merus 4 times as long as broad, inermous. Carpus 0.5 as long as merus, superior margin projecting into rounded tooth, inferior margin not projecting. Propodus 0.7 as long as merus bearing on its inferior margin 6 spines and a pair distally; lateral and medial surfaces bearing parallel patches of setae similar to *A. e. euphrosyne*. Dactylus 0.4 as long as propodus, spatulate; superior surface with low crest and a few tufts of setae.

Telson 2 times as long as posterior margin is broad; anterior pair of dorsal spines just anterior to midline.

DISCUSSION: As pointed out under *A. euphrosyne*, that species is adapted for muddy, brackish water conditions such as are found in mangrove swamps and is found exclusively in such habitats in the tropics of the western Pacific. Two other forms, described as *A. richardsoni* by Yaldwyn and *A. langi* by Schmitt (as *Crangon langi*, 1926:20) are morphologically almost identical and live in similar habitats, but are geographically separated, *A. richardsoni* living in temperate Australia and New Zealand, usually living in estuarine conditions, and *A. langi* at the month of the Congo. Dr Yaldwyn has compared his specimens from New Zealand with specimens from Australia for us, and we have examined the type series of *A. langi* through the courtesy of the American Museum of Natural History in New York. We are combining the three species under *A. euphrosyne*, but are considering the two separately described forms as geographically isolated subspecies. There is a third form morphologically indistinguishable from *A. e. richardsoni*, but it was found in a markedly different environment that we also discuss below.

The three subspecies may be separated by the characterists given in Table 5.

The most consistent differences are in the nature of the squame and the sculpturing of the small chela of the males. We have found these differences quite consistent in our examination of the holotype and topotypic specimens from all three subspecies, as well as the extensive series of *A. e. euphrosyne* from Thailand and the more than 300 specimens of *A. e. richardsoni* listed above from Australia. Dr Yaldwyn agrees that his *A. richardsoni* is the same as the Australian form.

The form reported from sea grass beds in New South Wales by Hutchings and Recher as *A. euphrosyne* was identified by us before we had made the distinction between the two subspecies; it is actually *A. e. richardsoni.*

We are troubled by 4 specimens from Arlington Reef (BAU 21) and 5 specimens from intertidal reef flat on Green Island Reef (AM 227), both off Cairns, Qld. These were from neither silty nor brackish conditions, yet morphologically they could not be distinguished from *A. e. richardsoni*. Moreover, they were found 10° further north than the northernmost record of *A. e. richardsoni*. However, they were markedly smaller than *A. e. richardsoni,* for none, including 3 ovigerous females were over 25 mm in length while *A. e. euphrosyne* and *A. e. richardsoni* both reach 65 mm in length at maturity. It is also notable that in the numerous collections made elsewhere along the Great Barrier Reef no other specimens of this form were found. We suggest two possible explanations for the occurrence of these 9 specimens: First, they may have matured out of their natural range and have been stunted by adverse ecological conditions. Second, and more plausible, they are yet another subspecies of the nominate species that has adpated to living in other than mud and brackish water, but that in this adaptation the external morphology has not been modified. If this latter hypothesis is true, then this form can be distinguished from the other subspecies only by its ecological preferences, body size and possible physiological adaptations. We do not speculate further but leave the problem for Australian carcinologists and ecologists.

BIOLOGICAL NOTES: Yaldwyn's type series came from "Mangrove swamps and from intertidal and shallow water mudflats" on both coasts of the northern part of the North Island, New Zealand. Similarly, the Australian specimens, where the habitat was noted in the collection data, came from muddy or silty conditions, often apparently in brackish water. The deepest collection were dredged at 22-24 m from "soft, silty substrate" in Port Phillip Bay, Victoria*. The specimens ranged up to 65 mm long.

In her doctoral thesis Ms KhinKhin U (1977 — see also p. 24) devoted most of her studies to the biology of *A. e. richardsoni* (under the name of *A. richardsoni*) living intertidally on a mud flat at Margate, Tasmania (near Hobart). To our knowledge this is the most comprehensive study on the general biology of a species of alpheid shrimp — as opposed to special studies on behaviour or embryology, etc. — yet made. With her permission we summarize some of her findings.

On the mudflats she found the population extending high in the intertidal zone (to mean highwater level of spring tides?); she did not investigate its penetration into the subtidal zone. She also reported their collection along the northern, eastern and southeastern coasts of Tasmania as well as from Flinders Island. The environment was found to have marked seasonal variations, with the temperature of the surface water ranging from 6° to 28°C, and the salinities from 14°/00 to about 35°/00. Laboratory studies showed that shrimp could tolerate even greater spans, but that the winter-adapted shrimp had a broader tolerance than those summer-adapted.

*Diane Brown of the Australian Museum sent us a single specimen of this species collected in 225 fathoms (412m) at 33° 40'S, 151° 53'E (southeast of Broken Bay, N.S.W.) by the F. R. V. **"Kapala"** (Australian Museum register number P. 19636).

The largest specimen she reported upon was only 42 mm long, considerably shorter than some from the coasts of Australia proper. She presented a tabulation and a discussion of the variations in proportions she found which showed that, like many other species in the Edwardsii Group, the species is fairly consistent in most proportions. She did find that in all cohabiting pairs the male had a proportionally larger large chela than the female.

Like many other species in the Edwardsii Group she reported *A. e. richardsoni* was a burrowing form, constructing a rather elaborate set of chambers and passages up to 30 cm below the surface. The shrimp preferred to initiate their burrows under a rock laying on the surface, but could burrow through the silt to reach a subsurface rock. In making the burrows both members of the cohabiting pair worked together. The mud was loosened by action of the walking legs and then fanned out of the burrow by the beat of the pleopods; during the process the large chela was thrust into the substrate as a brace. Smaller particles of shell or sand were carried out of the burrow with the small chela; the large chela was used only to push larger objects and at times to push sand and mud away from the entrance of the burrow. In aquaria a cohabiting pair was observed to maintain the same burrow for months. She did not find any symbiotic relationship with fish in the burrow.

She found from observation and stomach contents the species to be an opportunistic omnivore, eating fragments of *Zostera* (eel grass), various foraminiferans, polychaetes, a few molluscs and many crustaceans, including its own species. Observations on feeding behaviour showed that the food was probably detected by both pairs of antennae and was transferred to the mouthparts either by the chelae of the second legs (for small pieces) or by the small chela (for larger pieces). She did not observe the use of the large chela in the feeing process either in the production of sound or for grasping. She presented some excellent scanning electron photomicrographs of the armature of the third maxilliped. She found that in the field the shrimp would remain confined to the burrows during daylight but at night would leave the burrows for foraging. If the wandering shrimp attempted to retreat to the wrong burrow, the burrow would be defended by its rightful inhabitants by the snapping of the large chela.

Ms U also reported upon reproduction. She did not observe copulation and offered no explanation of the function of the balaeniceps dactylus of the males. The females were in berry the year around, but she found the eggs hatching only during the (southern) summer; some individuals, at least, would have two broods hatching during a single summer. The number of eggs carried was roughly a function of the size of the female, ranging by actual count from 7 to 1019. In reference to those earlier workers who used egg size as differentiating characteristic between species, she found the newly laid eggs to be round and 0.7 mm in diameter, while mature eggs, ready to hatch, were ellipsoidal with the diameters of 1.2 x 0.8 mm. After the brood hatches, the female moulted. The larvae hatched in an early zoeal stage, but she was unable to rear the larvae past a stage III zoea, reached in about one week. She could not estimate the life span of an individual, but did report that in an aquarium, sexually mature individuals had lived for over two years.

Finally, Ms U reported the colour in life (p. 29); "Upper side of the carapace green, abdomen banded with green and brown. Tail fan is also green with a tinge of dark blue at the tip. Large chela green on upperside, underside is white, inner tips of the fingers yellow."

AUSTRALIAN DISTRIBUTION: Except for the 9 specimens discussed above from near Cairns, all records of this subspecies were from temperate Australian waters,

running from Moreton Bay at Brisbane southward with many records in New South Wales, continuing through Victoria, Tasmania, South Australia and to the large brackish rivers systems in Bunbury and Perth in Western Australia.

GENERAL DISTRIBUTION: Australia and New Zealand.

Alpheus inopinatus Holthuis and Gottlieb*
Fig. 75

Alpheus inopinatus Holthuis and Gottlieb, 1958:42, figs. 8, 9. Tirmizi and Kazmi, 1969:99, fig. 1.

Alpheus sp. Forest and Guinot, 1958:6, figs. 3-7.

SPECIMENS EXAMINED: 1 specimen from AM 5 (AM P. 27833); 7, AM 30 (AM P. 27467); 7, AM 36 (AM P. 27566); 1, AM 62 (AM P. 28158); 2, AM 66 (AM P. 27786); 1, AM 74 (AM P. 28159); 1, AM 237 (AM P. 27795); 1, AM 292 (AM P. 27808); 12, AM 408 (AM P. 27567); 2, AM P. 2006; 2, AM P. 2218; 2, AM P. 10125; 1, AM P. 28160; 48, BAU 6; 21, BAU 7; 1, BAU 74; 8, JC 18; 13, JG 13-73; 3, JG 14-73; 4, QM W 2237; 5, US 123602; 1, VM 29; 1, WM 102-65, 1, WM 130-65; 1, WM 214-65; 1, WM 256-65; 1, WM 272-65; 1, WM 276-65; 3, WM 286-65.

DIAGNOSIS: Rostrum narrow, acute, reaching past middle of visible part of first antennular article; tip tilted upward. Rostral carina sharp, slightly depressed between the eyes and terminating at base of eyes. Orbitorostral grooves moderately deep. Visible part of first and third antennular article equal, second article 1.4 times as long and almost twice as long as broad. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with lateral tooth reaching beyond end of antennular peduncle, squamous portion narrow, reaching to end of antennular peduncle. Carpocerite stout, as long as lateral spine of scaphocerite.

Large chela stout, 2 times as long as broad with fingers occupying the distal 0.4, plunger of dactylus well developed. Superior saddle shallow, proximal shoulder gradually rounded. Lateral palmar depression well defined, quadrangular, reaching proximally to *linea impressa*. Medial palmar depression triangular, well defined, reaching to promixal third of palm. Inferior shoulder heavy, projecting slightly and rounded; both distal depressions triangular, that on lateral face smaller and better defined. Inferomedial margin of palm bearing long narrow groove from near proximal articulation almost to inferior shoulder. Merus 1.4 times as long as broad, distal margins inermous.

Small chela sexually dimorphic. Small chela of male balaeniceps, 3.0 times as long as broad, fingers and palm almost equal. Superior surface of palm with shallow, imperfectly defined superior saddle which runs proximally as a flattened area and is flanked on either side with heavy but low rounded crests. Palm with slight lateral depression, inferior shoulder strong. Strong tooth flanking dactylar articulation on medial side. Dactylus broadened with heavy fringe and strong proximal ridge, tip curved and crossing that of pollex, margins of pollex also bearing dense fringe of setae. Medial face of palm and pollex with scattered long hairs. Merus 2.0 times as long as broad, distal margins inermous, inferointernal margin bearing several setae. Small chela of female similar to male in proportions but dactylus not balaeniceps. Superior and inferior margins slightly notched proximal to dactylus. Medial face of fingers and distal portion of palm hirsute as in male. Merus similar to that of male.

Ratio of carpal articles of second leg: 10:7:3:3:5.

*(Note added in press). After a study of the variation found in a large collection of *A. lobidens* – *A. inopinatus* from the Red Sea we have come to the conclusion that the criteria set forth on p. 243 to separate the two nominal species are not valid and that *A. inopinatus* must be regarded as a junior synonym. The study also invalidated the separation of *A. lobidens* into two subspecies (see footnote, p. 252). We plan to publish the details of this study in a check-list of the alpheids of the Red Sea at some time in the future.

Fig. 75 *Alpheus inopinatus* Holthuis and Gottlieb
35 mm male from AM P. 4229. **a, b.** Anterior region, lateral and dorsal view; **c.** large chela, lateral face; **d.** large cheliped, medial face; **e.** small cheliped, lateral face; **f, g.** small chela, medial and superior face; **h.** second leg; **i.** third leg; **j.** telson. 40 mm female from WM 286-65. **k, l.** Small cheliped, lateral and medial face; a, b, j, l scale a; c, d, e, f, g, h, i, k scale b.

Ischium of third leg unarmed. Merus 3.2 times as long as broad, also unarmed. Carpus 0.6 as long as merus; superodistal margin slightly projected but rounded. Margins bearing a few long setae. Propodus 0.7 as long as merus bearing 7 spines along inferior margin and a pair distally. Dactylus simple, 0.4 as long as propodus.

Telson 2 times as long as broad posteriorly. Posterior margin slightly arcuate and bearing a number of small spines in addition to the usual fringe of long setae.

DISCUSSION: Our specimens agree well with the original description. The scaphocerite is a little longer in relation to the antennular articles, but this type of variation is common in the genus *Alpheus*. The spinules on the posterior border of the telson are not always evenly placed as in the figure of Holthuis and Gottlieb, but often appear to have random placement and variable number and in some specimens they are very small or even absent.

We question the separation of this species from *A. lobidens lobidens* de Haan. It appears to be separated by the following differences:
(1) *A. inopinatus* has a much stronger lateral tooth and more concave lateral margin on the scaphocerite. (2) In the large chela the inferior shoulder is much heavier and projects slightly forward while in *A. l. lobidens* the inferior shoulder is at right angles to the chela. (3) The superior groove on the palm of the small chela of the male in *A. inopinatus* does not have the typical "U"-shaped transverse groove (superior saddle) found in *A. l. lobidens,* but bears a longitudinal groove bounded by a lateral ridge that when it terminates distally gives the appearance of an incomplete notch. (4) The medial faces of the fingers of the small chela of both sexes in *A. inopinatus* are much more hirsute than in *A. l. lobidens.* (5) Finally the inferointernal margin of the meri of the large and small chelae are inermous distally except in very rare case in *A. inopinatus* while in *A. l. lobidens* they are usually armed. However, while "typical" *A. inopinatus* may be separated from "typical" *A. l. lobidens* by these differences, there are some specimens that lie intermediate in one or more of the characteristics. The two nominal forms co-exist in the same habitats, as well. We do not have enough specimens from the same habitats and localities to resolve the question and therefore must leave it to future workers.

Dr Forest of the Muséum National d'Histoire Naturelle in Paris has written us that he believes the specimen he and Guinot left unnamed in 1958 *(loc. cit.)* is of this species, therefore we are placing it in synonymy.

BIOLOGICAL NOTES: This species has been collected intertidally under rocks. It is often abundant as we collected over 50 specimens in two areas during a low tide at Yeppoon, Qld. In this collection were also some *A. l. lobidens.* It is a hardy species which according to Tirmizi and Kazmi, ". . . keeps well in small aquarium". Specimens reach 46 mm in length.

AUSTRALIAN DISTRIBUTION: This species was collected on the west coast from Perth to Gantheaume Bay, W.A.; in the north at Darwin and Thursday Island, and in eastern Australia from the Coral Sea to Grafton, N.S.W. Only one specimen was collected from the Great Barrier Reeef and that was from the Low Isles.

GENERAL DISTRIBUTION: Mediterranean coast of Israel and the West Pakistan coast.

Alpheus sudara Banner and Banner
Fig. 76

Alpheus sudara Banner and Banner, 1966b:153, fig. 59.

Alpheus crassimanus Tiwari, 1963:307, fig. 25, 26 *(partim).*

SPECIMENS EXAMINED: 2 specimens from AM 12 (AM P. 28133).

DIAGNOSIS: Rostrum short, not reaching to end of first antennular article; rostral carina sharp, but lying below level of orbital hoods in lateral view and extending to gastric region; carina terminated by slight protrusion in male specimen (protrusion lacking in female and in type series). Orbital hoods inflated, forming moderately deep grooves between carina and hoods. Second antennular article 2.5 times as long as broad, 2 times longer than visible part of first antennular article, third article subequal to first article. Stylocerite with lateral spine weak, but reaching almost to end of first antennular article. Scaphocerite with outer margins markedly concave, lateral spine reaching beyond antennular peduncle and well beyond narrow squamous portion which in turn reaches not quite to middle of third antennular article. Carpocerite equal in length to tooth of scaphocerite. Basicerite with strong lateral tooth.

Large chela stout, 2.4 times as long as broad, fingers occupying distal third. Proximal shoulder at right angles to, but not overhanging superior saddle; distal shoulder low and rounded; saddle broad. Lateral palmar depression quadrangular and well marked, extending to *linea impressa;* medial palmar depression a narrow triangle with apex extending to proximal quarter of palm. Inferior shoulder heavy and rounded; inferolateral depression "U"-shaped, narrow, deep and well defined; inferomedial depression roughly an equilateral triangle reaching about 0.4 breadth of palm bordered by low shoulder proximally that bears a few setae; distal margin indistinct. Pollex short and heavy, with distal oppositive margin on medial face lying at right angles to axis of palm and bearing dense fringe of long setae from dactylar articulation almost to short rounded conical tip. Plunger of dactylus of strong development. Merus 1.8 times as long as broad, without teeth on distal margins.

Small chelae showing sexual dimorphism. Small chela of male 3 times as long as broad, fingers 1.6 times as long as palm. Palm somewhat flattened on superior side, but without trace of superior saddle; inferior shoulder and notch strong. Dactylus articulated slightly laterally, medial side of articulation bearing moderate tooth. Dactylus bearing dense balaeniceps fringes of hair that meet on superodistal portion, but dactylus without the proximal expansion usually characteristic of balaeniceps condition; superior area set off by fringes with parallel sides except at tip. Superior crest of dactylus reaching almost to end of fringed area, but relatively low and rounded. Pollex also bearing rows of forward-sweeping dense setae longer than those of dactylus, meeting and overlapping dactylar setae. Tips of fingers hooked and crossing. Merus almost 2 times as long as broad with distal angles somewhat projecting but rounded. Small chela of females more slender, 2.8 times as long as broad and bearing only sparse hairs, tooth at dactylar articulation more acute than in male. Merus more slender and distal angles not as projecting.

Carpal articles of second leg with ratio: 10:7:3:3:4.

Ischium of third leg without spine, merus unarmed, 3 times as long as broad. Carpus 0.6 as long as merus, with neither margin distally projecting. Propodus 0.7 as long as merus, with 7 spines on inferior margin and a pair distally. Dactylus simple, 0.3 as long as propodus.

Telson 2.2 times as long as broad at posterior margin. Dorsal spines large.

DISCUSSION: The hair on the medial face of the dactylus and the pollex of the small chela of the male is much denser than in the specimens from Thailand, and also the

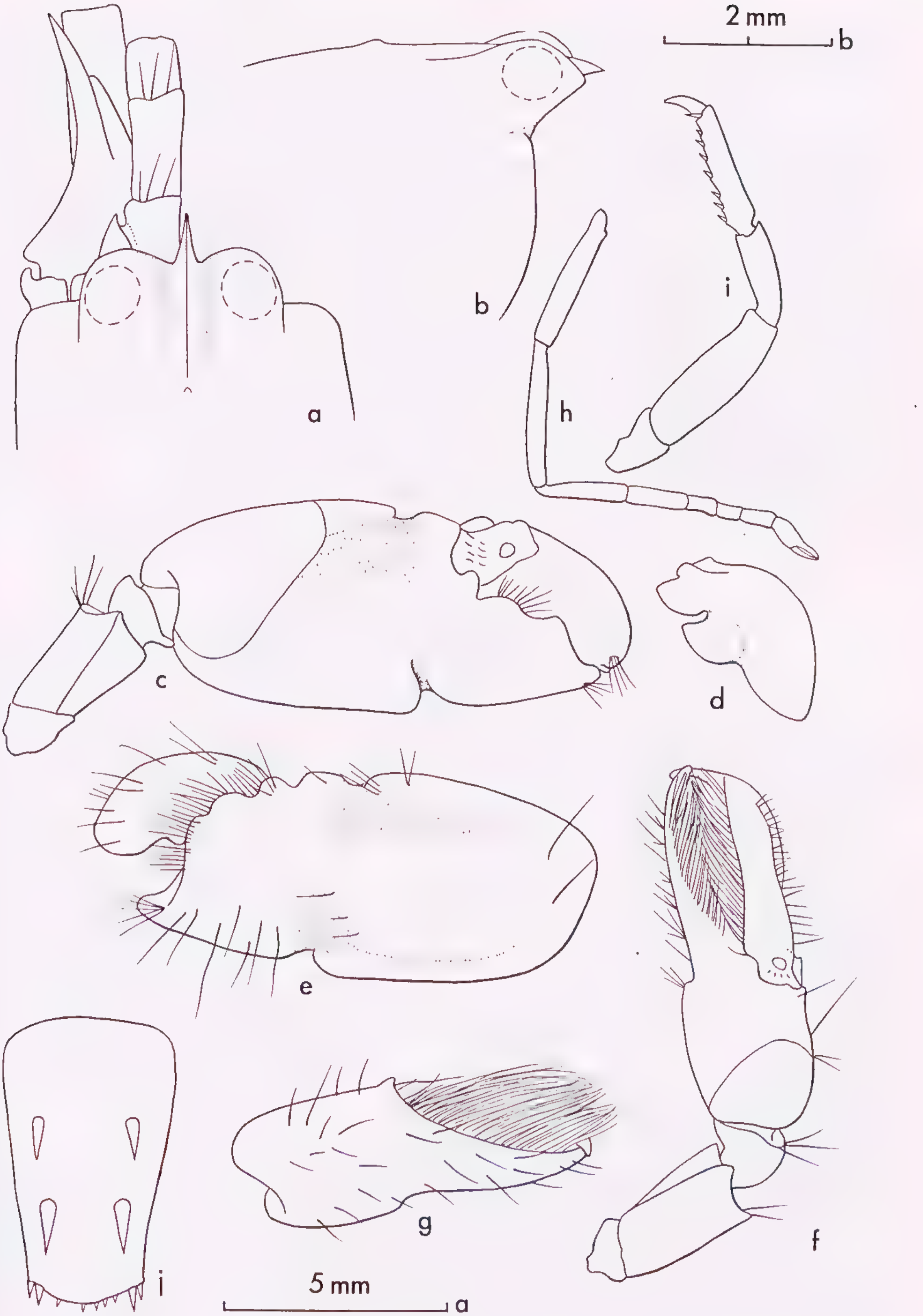

Fig. 76 *Alpheus sudara* B & B
25 mm male from AM 112. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large cheliped and dactylus, lateral face; **e.** large chela, medial face; **f, g.** small cheliped, lateral and small chela, medial face; **h.** second leg; **i.** third leg; **j.** telson. c, d, e, f, g, h, i scale a; a, b, j scale b.

superior groove on the palm of the large chela is broader. Finally, in both Australian specimens the rostral carina extends further posteriorly than in the Thai specimens and the posterior tubercle on the male carina was not seen before. With so few specimens and with their great similarity, we are considering these differences to be variation. However, when more specimens are examined, perhaps the Australian form may be considered to be a geographic race.

Tiwari (1963:307, figs. 25, 26) illustrates 2 specimens from Vietnam which he calls *A. crassimanus* (= *A. l. lobidens* De Haan). For remarks on the relationship of these specimens to *A. sudara* see discussion under *A. l. lobidens* (p. 252).

BIOLOGICAL NOTES: All specimens collected so far have come from the intertidal region or subtidally from coral heads. The larger specimen was 28 mm long; the Thai specimens reaching only 15 mm in length.

AUSTRALIAN DISTRIBUTION: Our specimens came from Port Curtis, Qld.

GENERAL DISTRIBUTION: Thailand and probably Vietnam.

Alpheus leviusculus leviusculus Dana
Subspecies designated
Fig. 77

Alpheus edwardsii leviusculus Dana, 1852:543, pl. 34, figs 3a-f.

Alpheus leviusculus De Man, 1911:411, fig. 98. Banner and Banner, 1964:92, fig. 4.

Alpheus bouvieri bastardi Coutière, 1898b:133, fig. 1a.

Alpheus bastardi Coutière, 1905a:907.

Nec Alpheus leviusculus Bate, 1888:549, 98, fig. 1 (= *A. batesi* Banner and Banner, 1964:92, fig. 94).

Also discussed:

Alpheus leviusculus bouvieri Milne-Edwards, subspecies designated. *Alpheus bouvieri* Milne-Edwards 1878:231.

Alpheus hululensis Coutière, new combination. *Alpheus bouvieri hululensis* Coutière, 1905a:908, pl. 85, fig. 46.

SPECIMENS EXAMINED: 2 specimens from AM 64 (AM P. 28134); 4, AM 123 (AM P. 28135); 2, AM 226 (AM P. 28136); 2, BAU 35; 2, BAU 46; 3, BAU 54; 6, BAU 56; 1, US 123564; 4, WM 104-65.

DIAGNOSIS: Rostrum broadly triangular and short, not reaching beyond middle of visible part of first antennular article; margin lateral to rostrum slightly concave and continuing into the almost straight front of orbital hoods. Orbitorostral grooves shallow and broad, interorbital rostral crest slight and rounded. Orbital hoods slightly inflated. Second antennular article up to 1.3 times as long as broad, longer than visible part of first and third article. Stylocerite short, acute, tip reaching to end of first article. Basicerite with strong but short lateral tooth, slightly shorter than stylocerite. Lateral margin of

scaphocerite almost straight; lateral tooth slightly exceeding third article, varying from slightly longer than, to well past squame. Carpocerite thick, exceeding length of antennular peduncle by length of third article.

Large chela 2.6 times as long as broad, fingers occupying the distal third. Superior saddle "U"-shaped with distal shoulder gently rounded and proximal shoulder varying from gently rounded to forming a right angle to margin of palm. Medial palmar depression small and "U"-shaped, lateral palmar depression triangular with apex reaching *linea impressa*. Inferior shoulder low and rounded, not projecting; inferior notch small, extending as faint depression into both lateral and medial faces. Plunger of dactylus well developed. Merus 2 times as long as broad, inferointernal margin rounded, bearing 2-3 short spines.

Small chela of male 3.6 times as long as broad, fingers slightly shorter than palm with medial tooth flanking dactylar articulation. In most males the dactylus is balaeniceps-shaped with characteristic rows of setae on lateral and medial faces that meet on dorsal surface. In other males these crests of hair are imperfectly developed. Pollex also bearing a slight fringe of hairs proximally. The female chela is more slender sometimes bearing a slight fringe of setae on dactylus (fig. 77k) and in others (fig. 77 n,o) the fringe of setae is lacking and the dactylus bears only random patches of hairs. Merus similar to that of large chela.

Carpus of second leg with ratio of articles: 10:7:3:3:5.

Third leg usually without spine on ischium. Merus unarmed and distally rounded, varying from 3.5-4.5 times as long as broad. Carpus 0.45 as long as merus. Propodus 0.6 as long as merus and bearing on its inferior margin about 7 spines and a pair distally. Superodistal margin bearing either a few long setae or one or two spines. Dactylus simple, occasionally bearing on ventral surface a slight thickening suggesting a secondary unguis.

Telson 2.3 times as long as broad posteriorly, posterior border slightly arcuate.

DISCUSSION: The name *A. edwardsii leviusculus* was applied by Dana to a specimen collected at Wake Island in the Pacific. *A. bouvieri* was applied by Milne-Edwards to specimens collected from the islands of Cape Verde Archipelago in the central Atlantic. Bate in 1888 applied the name *A. leviusculus* to a specimen from the Challenger Expedition that all future workers decided was not similar to that described by Dana. Coutière dealt with the complex twice. First (1898b:133) he reported the extension of the range of *A. bouvieri* to the west coast of Africa, to Fernando de Noronha in the Western Atlantic and to the Pacific coast of Panama. In the same paper he also described a new variety, *A. bouvieri bastardi,* from Madagascar, Djibouti and Panama (presumably also in the Pacific coast). In his second paper (1898h:249) he stated that *A. edwardsii* of Dana was not that of Audouin, but was *A. bouvieri* Milne-Edwards, and that Dana's *A. e. leviusculus* was merely an *A. bouvieri* with an anomalous chela. In spite of his rejection of *A. leviusculus* in this paper, Coutière recognized *A. leviusculus* as well as *A. edwardsii* and *A. b. bastardi* as occurring at Djibouti (1899:486). In this listing it should be noted that Lockington in 1878 (p. 474) created a homonym (or near homonym) by naming *A. laeviusculus* from California; according to Coutière (1909:21) this species was actually in the genus *Synalpheus* and to it he applied the name *S. lockingtoni.*

Subsequent references to the species complex were rather rare: Coutière (1905a:907) said that he could find no differences between *A. bouvieri* from the Maldives and the Milne-Edward's type from the "Canaries" (*sic*), and he described *A. bastardi* more fully from the Maldives, and raised it to species level. In the same paper he described *A.*

b. hululensis as a new variety and stated (p. 915) *"L'A. leviusculus* Dana *est probablement, comme le dit cet auteur, une simple variété de l'A. Bouvieri . . ."* De Man recognized one specimen from the Siboga Expedition as *A. leviusculus* (raising it also to the species level) and suggested that while it was definitely separate from *A. bouvieri, A. bastardi* might be a synonym. Coutière (1921:427) listed both *A. bouvieri* and *A. bastardi* as being collected by the Percy Sladen Trust Expedition in the Indian Ocean. Edmondson (1925:15) lists *A. leviusculus* as being collected from Wake, Hult (1938:3) from the Galapagos, and Barnard (1950:740) from Mauritius. *A. bouvieri* was listed by Holthuis in the Atlantide Reports (1951:81), but the name of this form was subsequently changed to *A. holthuisi* by Ribiero (1964:1). Forest and Guinot (1958:9) gave a partial redescription of Milne Edward's type series. Finally, to conclude this period, Holthuis (1958:28) reported *A. leviusculus* from the Red Sea with the remarks: "It is doubtful whether the Indo-West Pacific specimens assigned by Coutière to *A. bouvieri* actually can be distinguished from *A. leviusculus*" and suggested that the separation between the three species being here discussed should be revised.

In the late 1950's as we launched our studies of the Pacific alpheids we discovered we had a collection of 45 reasonably intact specimens that we considered to be *A. leviusculus,* including 5 specimens from Wake Island, the type locality, and 5 specimens in better condition from Johnston Island already reported upon by Edmondson (1925:15). To clarify the definition of the species we selected a 9.8 mm male to be designated a neotype and redescribed the species, and then on the basis of the other specimens at hand we made a study of the extent of variation in the series of specimens. This entire series of specimens and some of our original notes upon them were destroyed in a laboratory fire late in 1961 (1962:238) so we could not designate a neotype. Fortunately the complete manuscript which gave the description and the discussion had been prepared and was lying unpublished at the Bishop Museum in Honolulu; it was subsequently published (B&B, 1964).

We should note in passing that we failed to report the collection localities from the specimens other than the 13 reported in the 1964 paper. In going over the fire-ravaged and water-stained original notes we discover that some, if not most of the 32 specimens came from the Marshall Islands, principally Bikini and Enewetak (old spelling, Eniwetok) and at least one collection from Western Samoa; some may have been collected in other archipelagoes.

In the 1964 paper we compared the variation in *A. leviusculus* to the reported differences between the Altantic *A. bouvieri* and the Indian Ocean *A. bastardi,* and found that we could not distinguish between the nominal forms. We therefore placed the two younger names in synonymy; we reserved judgment on *A. bouvieri hululensis.* In 1966 we recorded and described the species from Thailand but did not discuss it further.

Also in 1964 Crosnier and Forest published their preliminary notes on the collections of the Calypso made in tropical eastern Atlantic, and stated that the specimens reported under the name of *A. bouvieri* from the Indo-Pacific were probably a different species. In their final report on the collections they gave excellent descriptions and figures of *A. bouvieri* and *A. bouvieri hululensis* (1966:273, 282 *et seq.*); they also gave a table separating seven species and forms they considered to be closely related, but they did not mention *A. leviusculus.* They gave 3 criteria that would separate *A. bastardi* from *A. bouvieri: A. bastardi* has a shorter rostrum with a more rounded and shorter carina, a broader and more rounded squame on the scaphocerite and finally *A. bastardi* has spines on the ischia of the third and fourth legs which are lacking in *A. bouvieri.* They suggested that Coutière's report of *A. bastardi* from Panama should be confirmed.

Chace (1972:63) recorded 26 specimens of *A. bouvieri* from various parts of the Caribbean and gave certain differences he found between our description and the range of variation we had given for *A. leviusculus* and the Caribbean specimens. These were:

	A. leviusculus	*A. bouvieri*
Large cheliped, merus	small tooth	rounded
palm, length/breadth	1.90	1.48-1.80; average 1.66
Small cheliped, male	rarely balaeniceps	always balaeniceps
Tooth of dactylar articulation	sharp	subrectagular or bluntly acute.
Second legs, carpus, ratio of 2nd to 5th article	second shorter	second 0.98 to 1.6 times fifth
Third legs, spine on ischium	present	absent

Chace also discussed some specimens from the Galapagos and Clipperton Island which he felt lay between *A. leviusculus* and *A. bouvieri,* and concluded ". . . it seems best for the time being to treat all forms (including the Eastern Pacific forms) as separate species."

We wish again to discuss these separations. We have some notes preserved of our original study on the 45 specimens, the 16 specimens listed above, approximately 10 specimens from Madagascar (some fragmentary) and one each from the Philippines, the Maldives and Hong Kong. We also examined specimens from the West Indies at the Smithsonian Institution.

ROSTRUM: Again we have found in the Australian specimens variation that encompasses the supposed differences set forth, with some specimens from the Coral Sea (AM 64 and AM 226) corresponding to the condition reported for *A. bastardi,* while some of the specimens from Heron Island (BAU 54) are similar to Coutière's figure for *A. bouvieri*. Most of the specimens again were intermediate.

SCAPHOCERITE: The variation in the breadth of the squamous portion and the curvature and length of the lateral spine in the Australian specimens again was like that reported in 1964, and encompasses the differences cited by other authors.

LARGE CHELIPED: In our original tabulation of the 45 specimens we measured only the total length-breadth ratio of the chela, not the length-breadth ratio of the palm, but our figures give an indication of the variation: of 36 specimens with the chelae intact, the average length-breadth ratio was 2.63, but the range was 2.1-3.0. In the figure we drew of the "neotype-to-be" the length-breadth ratio of the entire hand was 2.76 and that of the palm 1.88. If we are to presume that the other 35 specimens had the same relative finger lengths (which, of course, they would not have), then the average palmar ratio would have been 1.78 and the range would have been 1.43-2.05. This average is within 0.12 of Chace's average and the range extends on either side beyond Chace's range. Similar variation was found in the Australian specimens, but they were not measured.

The small tooth on the merus usually was present in the central Pacific and Australian specimens, but it varied in size and at times was lacking; in one pair, probably cohabiting (AM 64), the end of the merus in the female was rounded while it had an acute tooth in the male.

SMALL CHELA: The male Australian specimens showed a greater range of variation in the degree of the balaeniceps condition than did those originally studied. For example, 2

males from the Coral Sea had a definite balaeniceps-type fringe of setae, but did not have the great lateral expansion found in other specimens, while none of the 5 males with small chelipeds present collected from Heron Island bore more than short setiferous crests as described for the Wake Island specimens.

In our notes about the original 45 specimens we wrote "spine at (dactylar) articulations somewhat blunt, sometimes sharp, always present". We are not sure whether this means any were "subrectangular", but it does overlap Dr Chace's "bluntly acute".

CARPUS, SECOND LEGS: We did not measure the relative lengths of the second and fifth carpal articles in our initial study, but we did measure the relative lengths of the first two articles in 36 specimens with these legs intact. Here the ratio was 10:4.4. to 10:6.3 with the average of 10:5.7. It is worthy to note that Crosnier and Forest stated that they found the first article to be 1.65-2.5 as long as the second in *A. bouvieri,* which if converted to the ratio we are using, it would be 10:4.0-10:6.1. We measured the second to fifth articles of 5 Australian specimens taken at random and found the second articles to be equal to the fifth in 2 specimens and 1.06, 1.15 and 1.19 times as long in the other three — thus the Australian specimens have a longer second article than the one drawn from Wake. In six specimens from the Caribbean studied at the Smithsonian, 3 had the second and fifth articles equal, two had the ratio of 1.1 and one had an anomalous 1.46.

A re-examination of the original data showed another interesting thing: 6 specimens collected in Western Samoa (BBS6) all had markedly shorter second articles when compared to the first: their ratios ran from 10:4.4-10:5.8, with an average of 10:4.8, and if these were removed from the 36 previously averaged, the average would be 10:5.9. This may indicate a geographically distinct race but we would be loathe to consider it of taxonomic importance.

ISCHIUM OF THIRD LEGS: Both Crosnier and Forest and Chace regard the presence of a spine on the ischium in *A. leviusculus* or *A. bastardi,* and its absence in *A. bouvieri* as important; indeed, Chace stated that the characteristic is "perhaps of most importance". Unfortunately, we did not consider this in our original study and we now do not know how consistently the specimens in the Central Pacific were in the characteristic. The specimens we drew from Thailand lacked the spine. In 13 randomly selected specimens from Australia, 5 carried ischial spines, 8 did not.

Thus again we find that there are no firm characteristics to differentiate the specimens from the Atlantic and from the Indo-Pacific. Yet it is inconceivable that in recent geological time this species, like other circumtropical species of non-pelagic marine life could have been able to maintain a common gene pool. One of us (DMB) after examining the specimens from the Caribbean at the Smithsonian, was struck with subtle differences between these and the familar Indo-Pacific specimens and wrote in her working notes "Think FC (Fenner Chace) is right about the species from the Caribbean." Thus, we conclude that *A. leviusculus* should be divided into at least two geographically separate subspecies, *A. leviusculus leviusculus* and *A. leviusculus bouvieri* which probably can be distinguished by differing norms in distribution curves of variable characteristics, but not by any single firm difference.

In 1964 we renamed as *A. batesi* the specimen from the Philippines that Bate had listed in the Challenger Report as *A. leviusculus;* it evidently has not been collected since that time. In the same paper we suggested that *A. bouvieri hululensis* might be a species separate from *A. leviusculus.* Since that time, through the courtesy of the Muséum National d'Historie Naturelle of Paris, we were able to examine Coutière's holotype from

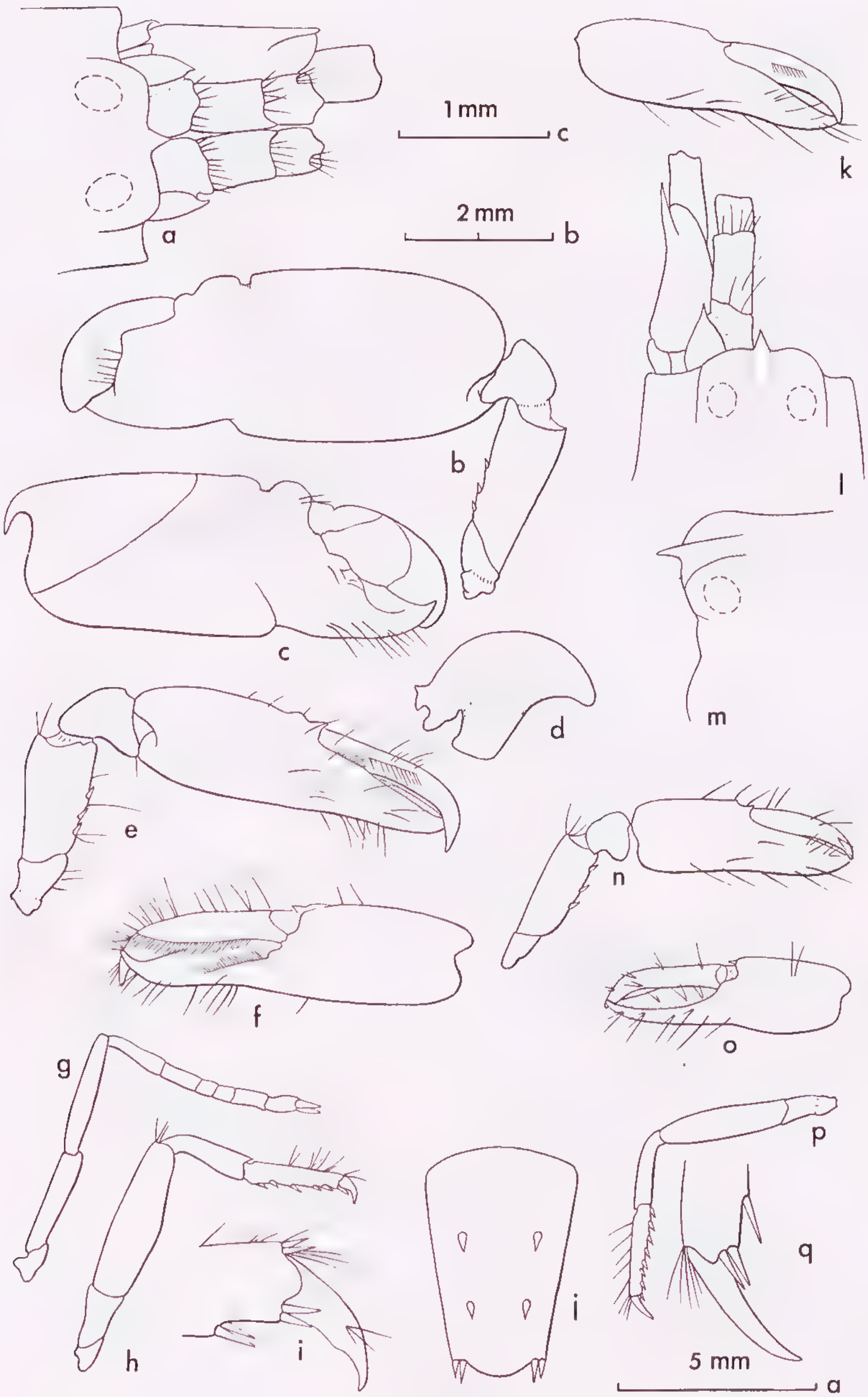

Fig. 77 *Alpheus leviusculus leviusculus* Dana
25 mm male from AM 226. **a.** Anterior region, dorsal view; **b.** large cheliped, medial face; **c, d.** large chela and dactylus, lateral face; **e, f.** small cheliped, medial and lateral face; **g.** second leg; **h, i.** third leg and dactylus enlarged; **j.** telson. 20 mm female from AM 226. **k.** Small chela, medial face. 24 mm female from BAU 54. **l, m.** Anterior region, dorsal and lateral view; **n, o.** small cheliped, medial and lateral face; **p, q.** third leg and dactylus enlarged. b, c, d, e, f, g, h, k, n, o, p scale a; a, j, l, m scale b; i, q scale c.

the Maldives, and now can say definitely that his description and figures of the anterior body region were accurate and not within the range of *A. leviusculus*. Also different were the ratios of the first two carpal articles; the difference in the small chela of the male is less reliable. (The holotype was also well figured by Crosnier and Forest, 1966: fig. 25a, b). Therefore we raise *A. hululensis* to specific level. We have not seen specimens of this species in any of our collections to date. Finally, we take no action on the possibly separate subspecies from the far eastern Pacific that was discussed by Chace.

BIOLOGICAL NOTES: Crosnier and Forest emphasized that *A. l. bouvieri* is intertidal and found under rocks on beaches of sand or gravel. Chace for the same subspecies, reported it both under rocks and in dead coral at or near the low tide level. The specimens in the collection we have studied, where the collection data is adequate, are similar in ecology. Most are reported from under stones, but some are from dead coral. In retrospect, some we personally collected from dead coral, as BAU 54, the specimens may have come from the fronds of the dead coral buried in the sandy substrate and not from the exposed portion of the head. All appeared to be intertidal or immediate subtidal. Yaldwyn notes that two specimens from the Coral Sea had "narrow green bands on abdomen, green on hands, green egg mass". The specimens ranged up to 28 mm long.

AUSTRALIAN DISTRIBUTION: The specimens were collected from Diamond Islet in the Coral Sea south to Heron Island in the Capricorn Group.

GENERAL DISTRIBUTION: The subspecies *A. leviusculus leviusculus* has been reported under one or another of its three names from the Red Sea, the islands of the central Indian Ocean, on to the islands of the central Pacific. While it reaches Wake Island, about 1000 km to the west south-west of Hawaii it does not reach the main Hawaiian Islands. The specimens reported (again under various names) from Clipperton, Panama and Galapagos, may not be of this subspecies.

Alpheus lobidens lobidens De Haan*

Fig. 78

Alpheus lobidens De Haan, 1850:179. Ortmann, 1890:474, pl. 36, fig. 13. Coutière, 1897e:199.

Alpheus lobidens lobidens Banner and Banner, 1974: fig. 31.

Alpheus crassimanus Heller, 1865:107, pl. 10, fig. 2. Bate 1888:554, pl. 99, fig. 2. De Man, 1902:880, pl. 27, fig. 62, 62a. Kemp, 1915:299. Barnard, 1950:756, fig. 144. Banner, 1959:147, fig. 11. Banner and Banner, 1966b:138, fig. 52. Forest and Guinot, 1958:6, fig. 1, 2. Tiwari, 1963:307, fig. 25, *(Partim)*.

Crangon crassimanus Banner, 1953:134, fig. 49.

Nec Alpheus crassimanus Fourmanoir, 1958:119, fig. 5 (=*Alpheus edwardsii* (Audouin)).

Previous Australian record:
Bate *loc. cit.* Cape York *(as A. crassimanus)*.

SPECIMENS EXAMINED: 4 specimens from AM 7 (AM P. 27541); 4, AM 13 (AM P. 27527); 2, AM 23 (AM P. 27556); 2, AM 93 (AM P. 27891); 2, AM 124 (AM P. 27809); 1, AM 198 (AM P. 27552); 1, AM 206 (AM P. 27540); 10, AM 213 (AM P. 28161); 14, AM 223 (AM P. 27892); 2, AM 234 (AM P. 27539); 1, AM 244 (AM P. 27564); 1, AM 250 (AM P. 27787); 2, AM 255 (AM P. 27810); 5, AM 277 (AM P. 27537); 6, AM 278 (AM P. 27457); 5, AM 291 (AM P. 27538); 4, AM 304 (AM P. 27925); 1, AM 305 (AM P. 27774); 1, AM 345 (AM P. 27811); 11, AM 350 (AM P. 28162); 1, AM 391 (AM P. 27763); 1, AM 393 (AM P. 27856); 2, AM 404 (AM P.

*A. lobidens is no longer to be separated into two subspecies and *A. inopinatus* Holthuis and Gottlieb is to be considered a synonym — see footnote on p. 241.

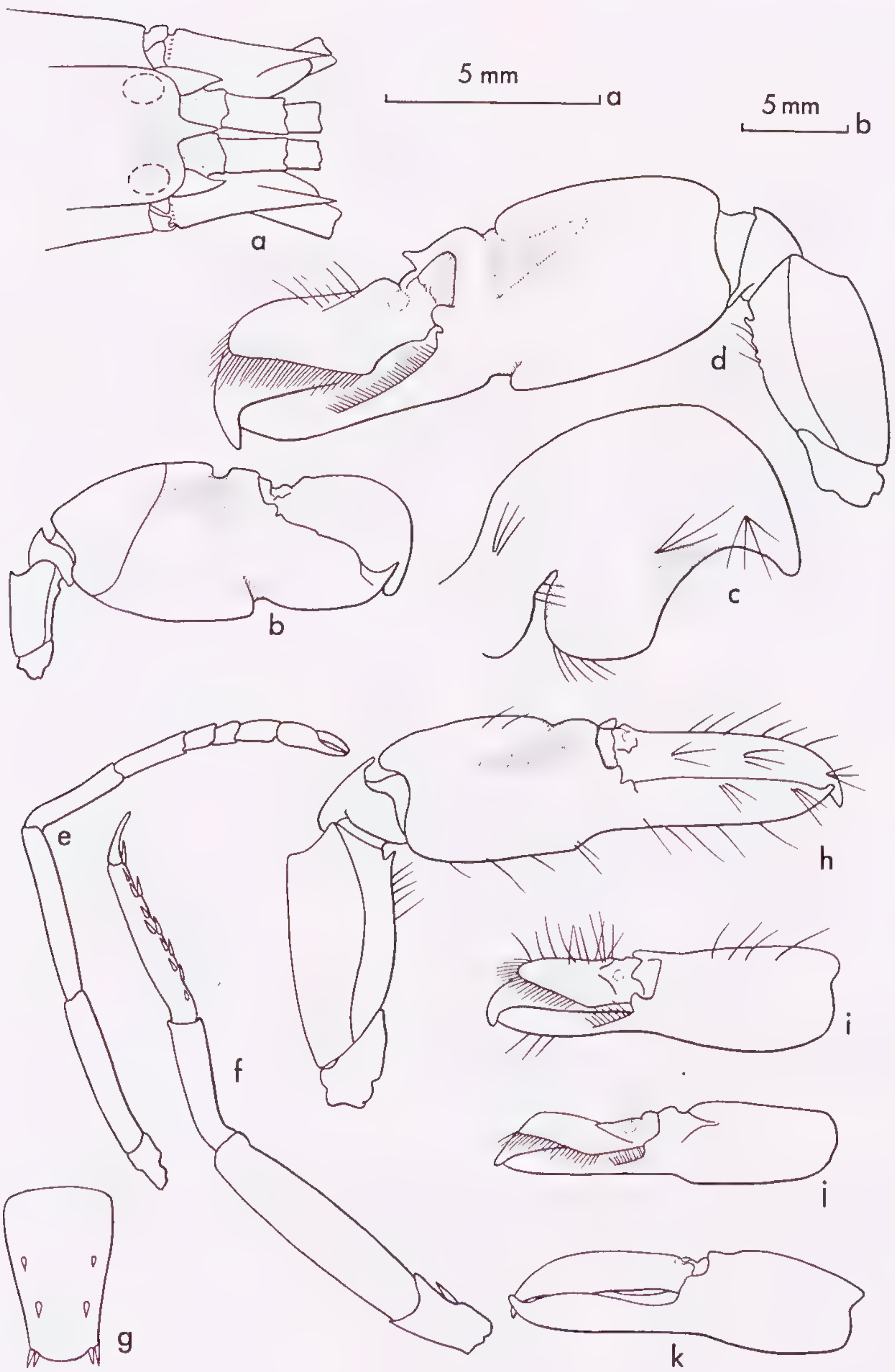

Fig. 78 *Alpheus lobidens lobidens* De Haan
40 mm male from AM 213. **a.** Anterior region, dorsal view; **b, c.** large cheliped, enlarged dactylus, lateral face; **d.** small cheliped of male, lateral face; **e.** second leg; **f.** third leg; **g.** telson. 38 mm female from AM 213. **h.** Small cheliped of female, lateral face. Small chela, lateral face; **i.** 24 mm male from BAU 36, showing lack of palmar grooves; **j.** 26 mm male from US 123567, showing minimal grooves; **k.** 31 mm female from AM 13 showing very slight sculpturing. a, c, d, e, f, g, h scale a; b, i, j, k scale b.

27893); 5, AM P. 3127; 2, AM P. 5215; 4, AM P. 8009; 3 AM P. 13561; 2, AM P. 13569; 1, AM P. 27452; 13, BAU 2; 12, BAU 8; 19, BAU 9; 1, BAU 23; 1, BAU 25; 7, BAU, 26; 34, BAU 34; 2, BAU 36; 8, BAU 41; 13, BAU 45; 4, BAU 46; 8, BAU 59; 3, BAU 72; 5, BAU 73; 4, BAU 74; 13, BAU 75; 6, JB 1; 2, JC 1; 6, JC 2; 2, JC 9; 2, JC 13; 1, JC 19; 2, JC 21; 1, JC 26; 3, JC 27; 9, JG 6-73; 1, JG 7-73; 3, JG 10-73; 1, JG 17-73; 4, MM 72; 2, QM W 1224; 3, QM W 2234; 4, QM W 2240; 15, QM W 2391; 1, UQ 21; 3, UQ 23; 1, UQ 27; 1, US 106163; 1, US 106166; 2, US 123567; 6, US 123568; 1, US 123602; 20, US 123603; 1, WM 36-65; 1, WM 142-65; 7, WM 275-65.

DIAGNOSIS: Rostrum acute, triangular, varying from 1.1 to 1.7 times as long as broad reaching almost to end of first antennular article. Orbitorostral grooves shallow and rounded. Second antennular article usually about 2 times as long as broad and varying from 1.3-2.0 times length of first; third varying from 0.6 to equal length of first. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with lateral tooth reaching just beyond antennular peduncle; squamous portion reaching end of antennular peduncle. Tip of carpocerite reaching to end of lateral tooth of scaphocerite.

Large chela similar to *A. australiensis sp. nov.* (see below p. 256).

Small chela sexually dimorphic. Male chela balaeniceps, varying from 3.1 to 4.7 times as long as broad. In fully mature specimens the palm usually bears sculpturing similar to that of large chela but reduced; in smaller males sculpturing is greatly reduced and may be almost entirely absent. Female chela not balaeniceps, varying from 3.5-4.7 times as long as broad. Sculpturing on palm varying with maturity of female, with larger specimens bearing superior indentation and inferior shoulder strong but less developed than in large males while in smaller females all sculpturing may be lacking.

Ratio of carpal articles of second legs varying as indicated: 10:(6-8):(3-4):(3-4):(4-5).

Ischium of third leg usually with movable spine. Merus inermous, varying from 3.5-5.0 times as long as broad. Distal margins of carpus not produced into acute processes. Propodus usually with about 10 spines. Dactylus simple, slightly curved.

Telson 2.3 times as long as posterior margin is wide, spines on upper surface small.

DISCUSSION: After examining topotypes of *A. lobidens* we found *A. crassimanus* to be a junior synonym. Then, examining collections of *A. lobidens* from the Indo-Pacific area, including Australia, we separated the species into two geographic subspecies: *A. l. lobidens* and *A. l. polynesica* (1974:429). The principal difference between the two rested in the sculpturing of the small chela of the mature males. In *A. lobidens* the superior margin of the palm proximal to the dactylar articulation is notched similar to that of the large chela and opposite this on the inferior margin is a strong shoulder with the groove extending into the medial face. In *A. l. polynesica* these grooves are only slight constrictions in the outlines. However, the smaller males of *A. l. lobidens* are similar in sculpturing to *A. l. polynesica*. *A. l. lobidens* occurs in the western Pacific and Indian Ocean, *A. l. polynesica* has only been collected in the central Pacific. This same type of variability was described by us for specimens of *A. e. euphrosyne* from Thailand (B&B, 1966b:130).

In this paper we are describing a new species, *A. australiensis* (p. 256), as closely related to *A. l. lobidens* and we are questioning the separation of *A. inopinatus* Holthuis and Gottlieb from *A. l. lobidens* (p. 241).

In a group of 11 specimens from near Brisbane, Qld. (AM 350) the inferointernal margin of the merus of the large cheliped was inermous distally. However, as they resembled in every other character *A. l. lobidens*, we interpret this as a variation.

Tiwari (1963:307) described 2 males as *A. crassimanus* which we believe are two different species. The "short male" he described exactly agrees with *A. sudara,* a species we described from Thailand (1966b:153, fig. 59; see also p.372 above). In his plates, figures 25a, d and 26b, c, d, e are figures of *A. sudara.* The "long male" he describes is probably the true *A. l. lobidens* and is represented in his plates by figures 25b, 25c and 26f. Fourmanoir (1958:118, fig. 5) records on some specimens as *A. crassimanus* from Nosy Bé Madagascar. He figures the large chela with the distal margin of the grooves on both the superior and inferior margins as being projected and subacute, a condition that never occurs in *A. lobidens.* We feel these specimens were, in all probability, *Alpheus edwardsii* (Audouin).

BIOLOGICAL NOTES: Barnard (1950:758) remarks on the colour of his live specimens, "Greeny-brown, olive green, or smoky-grey, anterior parts of abdominal segments often white (producing a banded appearance), with or without longitudinal stripes (a median and 2 lateral) on each segment, the lower lateral stripe runs along the lower margins of the pleura and is often edged with black, a black spot in middle of the side on segments 2 and 4; telson and uropods apically blackish; chelae greeny-orange or greeny-brown, finger and thumb of large chela orange, tips dull violet, palm with a more or less brilliant cobalt-blue patch on inner (upper) surface; other legs dull pinkish" Kemp (1915:301) also remarked on the black spots on each side of the second and fourth abdominal segments.

Kemp (*loc. cit.* p.300) found in his specimens from Chilka Lake that the species has an adaptability to extreme salinity changes. He found that although the species lives under rocks it does not produce an elaborate burrow, but simply makes a horizontal tunnel not more than a few inches in length. Farrow (1971:482), on the other hand, reports that at Aldabra the burrows in the carbonate sand are elaborate with the main tunnel lying horizontal 8-13 cm below the sand and with several sets of dichotomously branched entrance burrows reaching to the surface. He does not give the length of the horizontal portion of the burrow, but if one estimated from an approximatley 10 cm depth in his figure 17a, the burrow is near a half metre long. McNae (1957:361) reports in South Africa they inhabit radiating burrows to the depth of 25 cm. Farrow, McNae and others have reported that this species lives in associaton with gobiid fish (see also discussion on p. 182).

Almost all our our specimens were collected intertidally, but we do have 4 specimens that were captured in a prawn trawl at 14 fathoms in the Gulf of Carpentaria (AM 13), presumably they had been living in the mud on the bottom. This species is also occasionally found in the bases of dead coral heads. Our largest specimen attained the length of 44 mm but Barnard (1950:758) reports on specimens up to 55 mm in length.

AUSTRALIAN DISTRIBUTION: Our specimens have come from all warmer parts of Australia: Houtman Abrolhos, Darwin, Gulf of Carpentaria, Torres Straits and on down the east coast to Sydney, N.S.W. We also have 17 specimens from Lord Howe Island.

GENERAL DISTRIBUTION: This species ranges throughout the entire Indo-Pacific area from the Red Sea to Hawaii, but the subspecies does not occur in the central Pacific area. Forest and Guinot (1956:102) reported the species under *A. crassimanus* from Tunisia; it may have reached the Mediterranean via the Suez Canal.

Alpheus australiensis sp. nov.
Fig. 79

HOLOTYPE: 33 mm male from Caloundra, Qld., collected by A. A. Livingstone 14/8/22. (AM P. 6352).

ALLOTYPE: 26 mm female from the same locality as the type. (AM P. 27264).

PARATYPES: 1 specimen from AM 46 (AM P. 27205); 11, AM 126 (AM P. 27221); 2, AM 144 (AM P. 27220); 1, AM 150 (AM P. 27202); 4, AM 167 (AM P. 27222); 3, AM 216 (AM P. 27203); 1, AM 349 (AM P. 27201); 10, AM 350 (AM P. 27248); 2, AM 406 (AM P. 27204); 1, AM P. 10980; 1, AM P. 27254; 13, AM P. 27255; 16, BAU 63.

DESCRIPTION: Rostrum conical, about as long as wide at base, reaching somewhat past middle of visible part of first antennular article. Rostral carina rounded, extending posteriorly to base of eyes. Orbital hoods not markedly inflated with frontal margin somewhat convex; orbitorostral grooves moderate. Ratio of antennular articles beginning with visible part of first antennular article 10:13:10; second antennular article 1.4 times as long as broad. Stylocerite acute, reaching to end of first antennular article. Squamous portion of scaphocerite moderately wide, reaching end of antennular peduncle; lateral tooth a little longer, outer margin straight. Carpocerite reaching length of third antennular article past that article. Basicerite with acute lateral tooth.

Ratio of articles of third maxilliped: 10:4:6. Second article bearing only long hairs on inner face.

Large chela 2.4 times as long as broad, fingers occupying the distal 0.4. Superior saddle broad and relatively shallow, proximal shoulder usually gently rounded but at times almost abrupt, distal shoulder always gently rounded. Medial palmar depression a well-marked triangle whose apex reaches half the distance from saddle to proximal end of palm. Lateral palmar depression quadrangular, reaching to *linea impressa*. Inferior shoulder heavy and rounded; inferior notch broadly "U"-shaped, continuing on lateral face of palm as a well-defined but small triangular depression with rounded apex, and on medial face as a longer, broader, but less well-defined depression. Plunger pronounced. Merus a little longer than broad, bearing no teeth distally on inferointernal margin.

Small chela of male 3.0 times as long as broad, dactylus balaeniceps, fingers only slightly shorter than palm, both superior and inferior margins of palm with shallow, rounded indentations proximal to fingers. Medial side of dactylar articulation bearing acute tooth. Superior margin of dactylus with a slight subacute carina that disappears where the crest of hairs meet on the superior surface. Merus 1.7 times as long as broad with distal margins inermous. Small chela of female similar to male, 3.4 times as long as broad with fringe of setae well developed on medial and lateral margins of dactylus, but not reaching beyond two-thirds length of dactylus and not meeting at crest. Merus similar to male but 2.3 times as long as broad.

Ratio of carpal articles of second leg: 10:9:3:4:4.

Ischium of third leg armed with spine. Merus inermous 4.3 times as long as broad. Carpus 0.5 as long as merus; superior and inferior margins slightly projected distally. Propodus 0.7 as long as merus bearing 7 spines on inferior margin and a pair distally. Dactylus simple, slightly curved, 0.3 as long as propodus.

Telson 2.5 times as long as posterior margin is broad. Dorsal spines of moderate size.

DISCUSSION: It is with considerable reluctance that we are naming this as a species separate from *A. lobidens lobidens* De Haan and *A. lobidens polynesica* Banner and

Banner (1974:429). We separated the nominate species from the subspecies on the basis of the small chelae of mature males which carry heavy sculpturing in the nominate species that is entirely lacking in the subspecies. The two subspecies are geographically separated, with the nominate form being found in the far western Pacific (including Australia) to the Red Sea and *A. l. polynesica* being confined to the archipelagoes of the central Pacific. The central Pacific subspecies never reaches the large size at maturity attained by the western subspecies.

A. australiensis can be firmly separated from the two subspecies of *A. lobidens* only by the characteristics of the small chelae of the males and females. Like *A. l. polynesica*, the males of mature size lack the sculpturing on the small chela, and unlike both subspecies the chelae of the females show balaeniceps development. These and other characteristics of less reliability are set fourth in Table 6.

This separation appears rather subtle and questionable, but in the more than 350 specimens of both sexes of *A. l. lobidens* and more than 60 specimens of *Alpheus australiensis* from Australia we have examined, never did we find mature males or females that were intermediate in the form of the small chelae. Moreover, never did we collect the two species together. It initially appeared to us that in those collections where sufficient ecological data was given, they showed a definitely ecological separation, with *A. l. lobidens* occurring in burrows in cleaner sand and more saline waters, and with *A. australiensis* occurring in more muddy sand and less saline conditions. This recalls the ecological separation of *A. heeia* B&B and *A. l. polynesica* in Kaneohe Bay in Hawaii *(op. cit.)* where the former species lives in the cleaner more saline sand and the latter lives in the more muddy estuarine conditions. If we could have established such ecological separation the two forms could have been regarded as other than sympatric, for a difference in ecological requirements might impose a more effective separation of gene pools than would a geographic separation by thousands of kilometres, especially to species with planktonic larvae. If such a separation could be established, then *A. australiensis* should be considered a subspecies of *A. lobidens*.

However, there were too many records, especially of *A. l. lobidens*, for which we had no ecological data, only a broad geographic designation. In addition the records of *A. l. lobidens* from our personal collections in the Darwin area (BAU 72-75 incl.) seemed to range from "typical *lobidens* grounds" as in BAU 73 to "typical *australiensis* grounds", a muddy estuarine flat bordered by mangroves, in BAU 75.

It is therefore with doubts that we are describing this form, so obviously related to the two subspecies of *A. lobidens*, as a separate species and we suggest that Australian workers in the future try to determine, possibly through studies on breeding or behaviour, whether this form is a true species, subspecies or merely an ecological variant.

In spite of its close relationship to *A. l. lobidens*, it might be well to contrast this subspecies to other species in which the small chela of the female may approach a balaeniceps condition. From *A. s. strenuus* Dana and *A. pareuchirus imitatrix* De Man it differs by the lack of sculpturing on the small chela of the male and the lack of distal teeth on the meri of the chelipeds. *A. edwardsii* (Audouin), according to Coutière, may have slight setiferous crests on the dactylus of the female (Coutière, 1905a:914 as *A. audouini*), but here at least the meri of the chelipeds of the male are always armed with teeth. *A. heeia* B&B also bears a trace of the setiferous crests, but in that species the inner faces of the second articles of the third maxillipeds bear spines, not setae.

The holotype, allotype and some paratypes will be placed in the Australian Museum,

TABLE 6

Difference between 2 subspecies of *A. lobidens* and *A. australiensis*

	A. l. lobidens	*A. l. polynesica*	*A. australiensis*
1. Length/breadth second antennular article	2.0	2.0	1.1-1.7
2. Small chela, mature male, palmar sculpture	Pronounced	Slight to absent	Slight to absent
3. Small chela, female dactylus	Not balaeniceps	Not balaeniceps	Sub-balaeniceps
4. Distal tooth on inferointernal margin of meri of chelipeds	Usually present	Present	Lacking

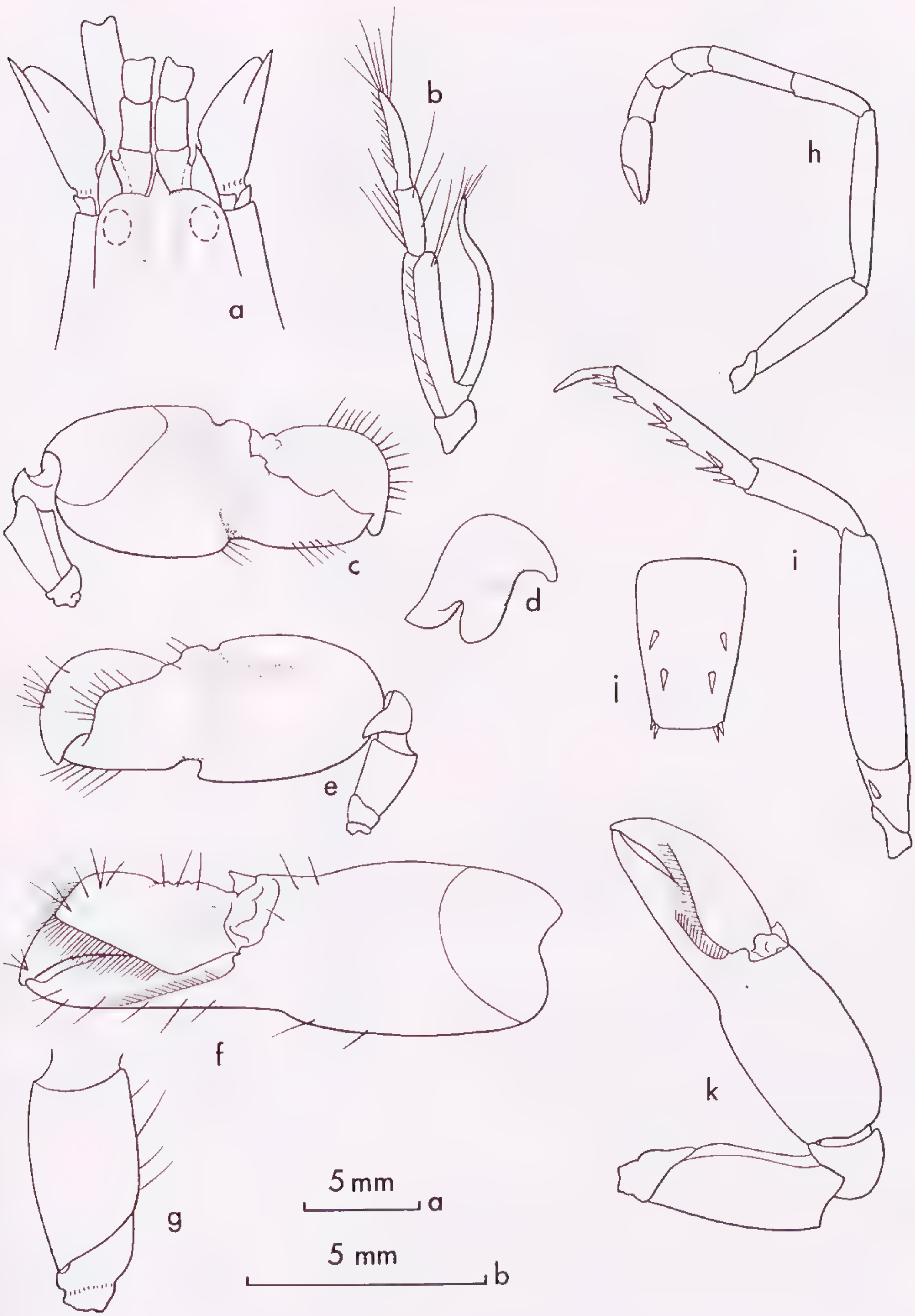

Fig. 79 *Alpheus australiensis* sp. nov.
Holotype (male) **a.** Anterior region, dorsal view; **b.** third maxilliped, lateral face; **c, d, e.** large cheliped medial and lateral face and dactylus; **f, g.** small chela and merus, lateral face; **h.** second leg; **i.** third leg; **j.** telson; Allotype (female) **k.** small cheliped, lateral face. c, d, e scale a; a, b, f, g, h, i, j, k scale b.

Sydney, N.S.W. Paratypes will also be placed in the National Museum of Natural History, Washington D.C., U.S.A.

BIOLOGICAL NOTES: These specimens were all collected intertidally, usually in estuarine conditions. They were found under rocks relatively free of mud and also in sandy-muddy conditions such as collection we made at the mouth of the Wilson River, at Pt. Macquarie (BAU 63). Our field notes state: "Plus 2.6 tidal level and above. In very soft muddy sand in eel grass beds. Substrate of such a consistency as to cause us to sink in 4-6" deep with each step. Burrow entrance in depression of surface, often concealed under short eel grass. Burrows not over 6" deep. Initially at an angle of 45° to surface and possibly extending horizontally, at times small gobys were found in the excavation. These alpheids are at times used for fish bait and are called popularly 'nippers'." In two collections colour notes indicate that the specimens were dark olive green and were not transversely banded as *A. l. lobidens* and *A. l. polynesica* are found to be. The specimens reached up to 35 mm in length.

AUSTRALIAN DISTRIBUTION: The 67 specimens were collected in about 1600 km of coastline reaching from the Whitsunday Group, Qld. to Sydney, N.S.W.

Alpheus papillosus sp. nov.

Fig. 80

HOLOTYPE: 28 mm male from Sandgate, Moreton Bay, Qld., 25/6/44. From J. S. Hynd collection. AM 114 (AM P. 27233).

ALLOTYPE: 31 mm ovigerous female from same collection as holotype. (AM P. 27232).

PARATYPES: 1 specimen from AM 13 (AM P. 27230); 13, AM 56 (AM P. 27212); 25, AM 70 (AM P. 27213); 2, AM 114 (AM P. 27231); 1, AM 117 (AM P. 27215); 4, AM 133 (AM P. 27218); 1, AM 142 (AM P. 27238); 1, AM 165 (AM P. 27219); 3, AM 168 (AM P. 27216); 2, AM 175 (AM P. 27223); 1, AM 219 (AM P. 27239); 1, AM 227 (AM P. 27217); 1, AM 256 (AM P. 27240); 2, AM 390 (AM P. 27237); 4, AM 391 (AM P. 27241); 2, AM 403 (AM P. 27224); 2, AM 445 (AM P. 27225); 1, AM 446 (AM P. 27242); 5, AM 450 (AM P. 27243); 1, AM 461 (AM P. 27227); 3, AM 462 (AM P. 27229); 1, AM 465 (AM P. 27228); 1, AM P. 836; 1, AM P. 5116; 1, AM P. 7234; 1, AM P. 8255; 1, AM P. 8695; 2, AM P. 9076; 3, AM P. 10770; 1, AM P. 11416; 1, AM P. 11440; 2, AM P. 11451; 1, AM P. 13563; 3, AM P. 13567; 1, AM P. 27262; 2, AM P. 27875; 1 specimen each from CS IIA3, IIIB1, IIID1, IIIE2; 3, QM W 835; 3, QM W 838; 3, QM W 1052; 1, US 106167; 5, US 123562; 2, US 123579; 1, US 123602; 1, UQ 4; 1, UQ 6; 1, UQ 11; 24, UQ 21; 1, WM 34-65; 6, WM 49-65; 1, WM 205-65; 2, WM 239-65.

DIAGNOSIS: Rostrum acute, triangular, almost twice as long as broad at base, reaching almost to end of first antennular article; lateral margin bearing a few short setae. Rostral carina rounded; orbitorostral grooves moderately shallow, disappearing at base of eyes; anterior margin of orbital hoods evenly rounded. Second antennular article 2 times as long as broad, 1.5 times as long as visible part of first article, third article a little shorter than visible part of first article. Anterior margins of antennular articles beset with strong setae. Stylocerite acute, reaching to end of first antennular article; scaphocerite with squamous portion moderately narrow, reaching past end of antennular peduncle, lateral spine reaching past squame by half the length of third antennular article. Carpocerite reaching half length of third antennular article beyond that article. Lateral spine of basicerite slender, acute, shorter than stylocerite.

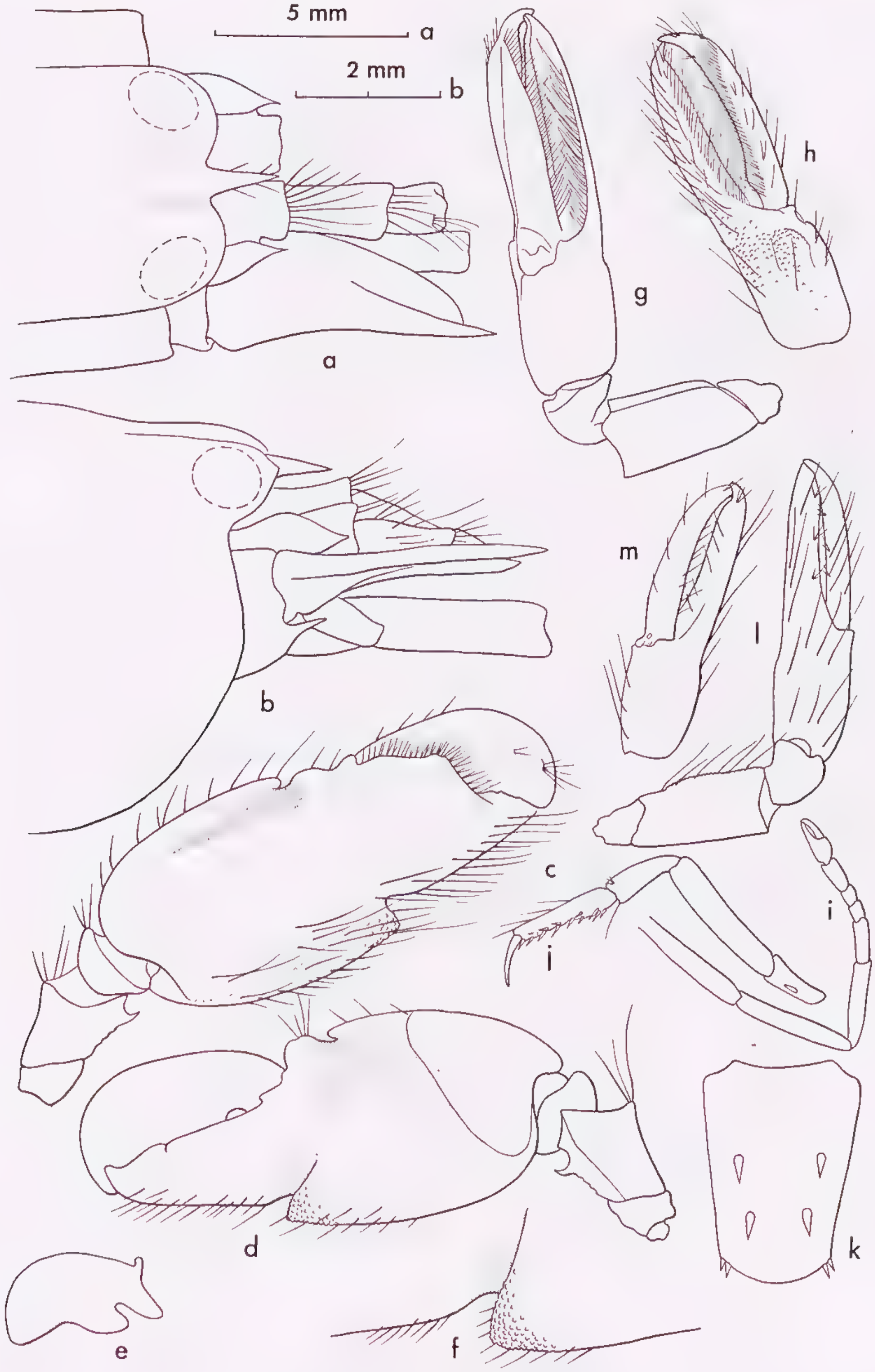

Fig. 80 *Alpheus papillosus* sp. nov.
Holotype (male). **a, b.** Anterior region dorsal and lateral view; **c, d.** large cheliped, medial and lateral face; **e, f.** large chela, dactylus, and enlargement of inferior midsection, lateral face; **g, h.** small cheliped, lateral face, and small chela, medial face; **i.** second leg; **j.** third leg; **k.** telson. Allotype (female) **l, m.** Small cheliped, medial and lateral face. c, d, e, g, h, i, j, l, m scale a; a, b, f, k scale b.

Articles of third maxilliped with ratio: 10:3:7. Inferior face of second article beset with fine setae.

Large chela compressed, 2.4 times as long as broad, fingers occupying the distal 0.4. Plunger of dactylus of moderate development. Superior saddle well defined, proximal shoulder overhanging, but not acute, and lying close to floor of saddle. Distal shoulder of saddle prominent, gradually rounded. Lateral palmar depression well defined, quadrangular, continued proximally to *linea impressa*. Medial palmar depression well defined, a narrow triangle with apex reaching to proximal quarter of chela. Inferior shoulder heavy, directed distally, in profile appearing as a heavy truncate lobe; inferodistal portion of lobe covered with papillae. Inferolateral depression well defined, continuing up lateral face for 0.3 total height. Medial face of palm bearing faint, narrow longitudinal groove from near proximal articulation to inferior notch. Chela bearing long, forward directed setae on face near inferior margin; setae continuing to region of pollex. Hirsute section of chela slightly papillose. Merus almost 2.0 times as long as broad; superodistal margin obtuse, inferointernal margin armed with strong acute tooth subterminally and setae proximally.

Dactylus of small chela of male balaeniceps, chela almost 4.0 times as long as broad, fingers 0.6 of total length. Superior surface of palm not rounded distally but appearing as a triangular flattened area demarked laterally by slight rounded ridge and medially by a low rounded crest that terminates before dactylar articulation; this development seen only in larger males. Medial face with long setae and low papillae; bearing slight tooth at dactylar articulation; lateral surface nearly smooth. Both fingers with dense rows of setae on margins of oppositive faces that cross at midpoint; setiferous crests of dactylus joining across superior margin near distal end. Dactylus bearing low, thin tooth on cutting surface near dactylar articulation. Inner face of chela bearing long fine setae, increasing towards proximal end, setae directed distally. Merus inermous, 2.2 times as long as broad. Dactylus of small chela of female not balaeniceps. Fingers 1.6 times as long as palm with short fine setae on oppositive surfaces that cross in the middle, inner face also beset with long, distally-directed setae similar to those of male chela. Surface of chela almost smooth. Merus 2.7 times as long as broad, inferointernal margin inermous but bearing a few setae along its entire margin.

Carpal articles of second legs with ratio: 10:5:2:2:3.

Ischium of third leg with spine. Merus inermous, 4.8 times as long as broad. Carpus 0.4 as long as merus, bearing a few setae distally and without extension of distal angles. Propodus 0.7 as long as merus, bearing approximately 14 spines, more or less in pairs, along inferior border. Dactylus simple, slender, 0.4 as long as propodus.

Telson almost twice as long as broad at posterior margin. Anterior margin 1.4 times as broad as posterior margin. Spines on upper surface prominent with anterior pair arising slightly anterior to middle. Spines on posterolateral angles small, posterior margin slightly arcuate.

DISCUSSION: This species more closely resembles *Alpheus pacificus* Dana than any other species in the Edwardsii Group. It differs in the following characters: (1) *A. pacificus* does not have a balaeniceps dactylus in the male small chela and the palm does not bear a shoulder on the medial face. (2) In *A. pacificus* the surface of the inferior shoulder of the large chela is smooth while in this species it is papillose. (3) The plunger of the dactylus on the large chela is much longer in *A. pacificus* than in this species. (4) The inferodistal margin of the merus of the large chela of *A. pacificus* is inermous while in this species it carries a pronounced subterminal tooth.

This species is also related to other members of the Edwardsii Group in which the small chela of the male is balaeniceps and the female is not; the male chela is less than 5 times as long as broad; the rostrum is not flattened above; the depression on the superointernal surface of the large chela is triangular instead of "U"-shaped; and the merus of the large cheliped is armed distally on the inferior margin. These species include *A. edwardsii* (Audouin), *A. chiragricus* Milne-Edwards, *A. lobidens lobidens* De Haan, *A. pareuchirus pareuchirus* Coutière, *A. leptochirus* Coutière, and *A. leptochiroides* De Man. It can be separated from all of these by the papillose shoulder on the inferior margin in the large chela, the papillose palm of the small chela in the male and the swelling near the superior margin proximal to the dactylar articulation.

This species is not subject to a great deal of variation. We have found that the ratio of the first two articles of the second leg varies from 10:5 to 10:8. In the young specimens the papillae of the chelae are not as numerous and also in the smaller male specimens the swelling on the medial face near the superior margin of the small chela is scarcely discernible.

The species of *Alpheus* that Hutchings and Recher (1974) placed under the designation *Alpheus* species B and C (table 2, 6) are *A. papillosus*.

The name *papillosus* refers to the papillae on the inferior shoulder of the large chela. The holotype and allotype will be placed in the Australian Museum, Sydney, N.S.W. The paratypes will be returned to the institutions that loaned them to us.

BIOLOGICAL NOTES: The habitat of this species is similar to that of *A. pacificus*, largely intertidal, under stones. However, it has been dredged as deep as 10 fathoms and was frequently taken in the prawn trawls of Moreton Bay. A colour note in the collection from US 106167 states "Abdomen with white stripe down side. Reddish to grey-green and white." We have specimens ranging from 22-40 mm.

AUSTRALIAN DISTRIBUTION: The specimens on the west coast came from Cockburn Sound and Exmouth Gulf. Four of the specimens came from the Gulf of Carpentaria. Five of the specimens came from near Kangaroo Is., South Australia. The rest of the specimens ranged on the east coast from Cairns, Qld. to Careel Bay, N.S.W. At present, the species is known only from Australian waters.

Alpheus bisincisus De Haan
Fig. 81

Alpheus bisincisus De Haan, 1850:179, pl. 45, fig. 3 (in text as *A. avarus* Fabricius, on plate as *A. bisincisus*). Pearson, 1911:182. Tiwari, 1963:304, fig. 23.

Alpheus bisincisus malensis Coutière, 1905a:910, pl. 86, fig. 48.

Alpheus bisincisus stylirostris Coutière, 1905a:911, pl. 86, fig. 49.

Alpheus bisincisus variabilis De Man, 1909a:109; 1911:406, fig. 95 a-e.

SPECIMENS EXAMINED: 1 specimen from AM E. 3159; 2, AM P. 7050; 2, AM P. 7711; 1, UQ 36; 1, WM 93-65; 1, WM 144-65; 1, WM 185-65.

DIAGNOSIS: Rostrum reaching almost to end of first antennular article; varying from 1.8-3.0 times as long as broad at base. Rostrum flattened dorsally with margins overhanging deep orbitorostral grooves and disappearing well posterior to eyes. Orbitorostral margin varying from slightly to abruptly concave. Visible part of first antennular article a little longer than third article, second article 1.5 times longer than

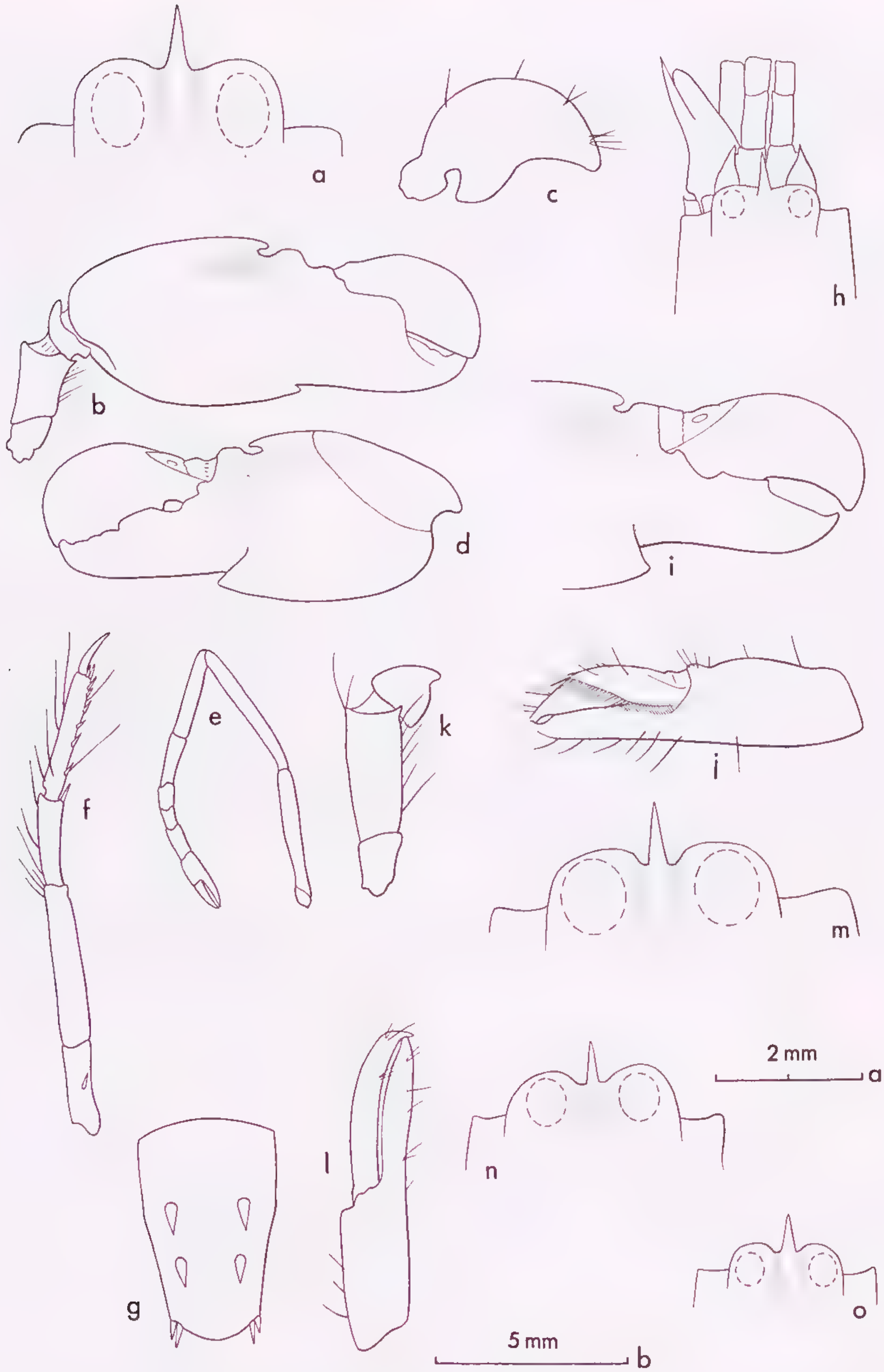

Fig. 81 *Alpheus bisincisus* De Haan
28 mm male from WM 144-65. **a.** Anterior region, dorsal view; **b, c.** large cheliped and dactylus medial face; **d.** large chela, lateral face; **e.** second leg; **f.** third leg; **g.** telson. 30 mm male from AM P. 7711. **h.** Anterior region, dorsal view; **i.** distal end of large chela, lateral face; **j, k.** small chela, lateral face, merus, medial face. 25 mm female from UQ 36. **l.** Small chela, medial face. 31 mm male from AM E. 3159. **m.** Anterior region, dorsal view. 34 mm male from AM P. 7050. **n.** Anterior region, dorsal view. 30 mm female from WM 185-65. **o.** Anterior region, dorsal view. a, g, m, n scale a; b, c, d, e, f, h, i, j, k, l, o scale b.

visible part of first antennular article and 2.0 times as long as wide. Stylocerite reaching to end of first antennular article. Scaphocerite with outer margin concave, lateral tooth extending well beyond narrow squamous portion and as long as antennular peduncle. Carpocerite as long as antennular peduncle.

Large chela 2.4 times as long as broad, fingers occupying distal 0.4. Palm broader than fingers. Plunger of dactylus of strong development. Proximal shoulder subacute, markedly overhanging superior saddle; distal shoulder gradually rounded. Lateral palmar depression shallow and quadrangular, extending to *linea impressa*. Medial palmar depression triangular, apex disappearing in the proximal third of chela. Inferior notch well marked; inferior shoulder strong, subacute, continuing 0.3 the distance up lateral face, with margin well defined. Near inferior margin of medial face is a narrow longitudinal groove that extends from inferior notch to proximal half of palm. Merus 1.6 times as long as broad, bearing long hairs and a strong tooth distally on inferointernal margin.

Small chela sexually dimorphic with that of male balaeniceps varying from 2.3 to 4.0 times as long as broad, fingers and palm almost equal in length. Superior margin of palm bearing shallow transverse groove proximal to dactylus. Fringes of setae on dactylus meeting on superior surface at distal third. Pollex bearing a fringe of short hairs extending from near point of articulation to middle. Merus 2.4 times as long as broad, bearing an acute tooth distally on inferointernal margin. Female chela not balaeniceps, 4.5 times as long as broad, fingers a little longer than palm. Merus 3.3 times as long as broad with tooth similar to that of males.

Carpal articles of second legs with ratio of: 10:7:2:2:3.

Third leg with spine on ischium. Merus inermous, 5 times as long as broad. Carpus 0.5 as long as merus, superodistal margin projected as a small rounded tooth; inferodistal margin bearing a slender acute spine. Propodus 0.8 as long as merus bearing 7 spines with a pair distally on inferior margin. Dactylus simple, 0.4 as long as propodus.

First four abdominal sterna of male bearing small flat processes extending posteriorly.

Telson 2 times as long as broad at posterior margin. Posterior margin slightly arcuate; dorsal spines large.

DISCUSSION: In addition to De Haan's original species, 3 varieties have been described; the criteria used in their separation are given in Table 7. The two varieties (*malensis* and *stylirostris*) described by Coutière were considered by Pearson in 1911 on the basis of variation he found in 10 specimens from Ceylon; he evidently did not have De Man's 1909a and 1911 publications for he did not mention *A. b. variabilis* of that author. He stated that the variation he found in his specimens encompassed the differences Coutière had set forth to separate the three forms. However, the rostrums in his specimens varied from 1.88 to 2.77 times as long as broad, none reaching the 3.5 ratio given by Coutière for his *A. b. stylirostris,* and he did not remark upon the lack of the balaeniceps development in the male of that variety.

In addition to the specimens from Australia, listed above, we were loaned 3 males and 3 females from Japan by Dr Miya of Nagasaki University; four came from near Amakusa which is near the presumed locality for De Haan's species, and two were from Sagami Bay near Tokyo. The variation we found in these specimens is listed also in table 7, with the variation in the Japanese specimens listed in parentheses after the figures deduced from De Haan's original description and plates.

TABLE 7

Criteria for the separation of described forms of *A. bisincisus* compared to range of variation in Japanese and Australian specimens
(Figures taken from texts and plates)

	A. bisincisus	*A. b. malensis*	*A. b. stylirostris*	*A. b. variabilis*	*Australian specimens*
Length/breadth of rostrum	1.5(1.5-2.6)*	1.5	3.5	3.0	1.8-3.0
Proportion between height of palm and fingers, large chela	1.34 (1.1-1.2)	1.6	1.34	1.54	1.1-1.4
Small chela of male:					
balaeniceps	yes (yes)	yes	no	yes	yes
total length/breadth	? (3.5-4.3)	4.7	4.85	4.2	3.2-4.2
length palm:length fingers	?(0.9-1.4)	0.7	1.0	0.8	0.9-1.0
Ratio of first and second carpal articles of second leg	10:7 (10:5-10:7)	10.6	10:7	10:5	10:5-10:7

*Figures in parentheses are from specimens from Japan; see text.

The comparison shows that variation in these specimens studied encompasses the three varieties except for the narrowness of the rostrum and the lack of a sexually modified small chela in *A. b. stylirostris*. However, we believe that the range of variation of the rostral length to breadth of the measured or described specimens, which runs from the ratio of 1.5 to 3.0, could easily be extended to Coutière's described 3.5 where more specimens are examined. The balaeniceps condition of the small chela of the male like other sexually dimorphic characteristics, is a function of size and sexual maturity. Coutière does not give the size of his sole specimen of *A. b. stylirostris,* but he does give a drawing (fig. 30a) of the small chela and its magnification. If the magnification (30x) is correct, then the chela itself is only 2 mm long, while the mature chela of *A. b. malensis* in fig. 31b is magnified by a factor of 12x and would therefore measure 4.8 mm. The shortest balaeniceps type chela present in our collection measures 8 mm. We believe that Coutière had a sexually immature male and that its small size might also be reflected in the narrowness of the rostrum; therefore we do not recognize any named varieties in De Haan's species, *A. bisincisus*.

This species is remarkably close to *A. chiragricus* Milne-Edwards and is only separated by the flattened rostrum that overhangs the rostral grooves and the subacute lobes that overhang the grooves on the large chela in this species.

BIOLOGICAL NOTES: This species has been collected intertidally and from mud and sand bottoms as deep as 25 fathoms. It has not been reported from dead coral heads. The specimen from Port Dennis (AM P. 7050) was hand netted in "weeds" and the specimen from Dampier Archipelago (WM 144-65) was inhabiting a sponge. Our specimen range up to 35 mm in length.

AUSTRALIAN DISTRIBUTION: We have specimens from northwest Australia, the Gulf of Carpentaria and southern Queensland.

GENERAL DISTRIBUTION: South Africa, Maldive and Laccadive Archipelagoes, Ceylon; Indonesia, Singapore and Japan.

Alpheus chiragricus Milne-Edwards
Fig. 82

Alpheus chiragricus Milne-Edwards, 1837:354. De Man, 1911:415.

*Alpheus Edwardsii** De Man, 1882b:266; 1897:745, pl. 36, fig. 64e; 1898b:312, pl. 4, fig. 1; 1902:880, pl. 37, figs. 62b, c *(passim)*. Coutière, 1905a:912, pl. 86, fig. 50 *(passim)*.

SPECIMENS EXAMINED: 4 specimens from AM 3 (AM P. 27821); 4, AM 42 (AM P. 28163); 1, AM 45 (AM P. 27832); 3, AM 114 (AM P. 27548); 1, AM 156 (AM P. 28102); 1, AM 193 (AM P. 27547); 1, AM 194 (AM P. 27546); 1, AM 200 (AM P. 27818); 1, AM 232 (AM P. 27588); 2, AM 280 (AM P. 27460); 5, AM 306 (AM P. 27461); 1, AM 312 (AM P. 27545); 1, AM 391 (AM P. 27764); 1, AM P. 9670; 5, AM P. 13550; 1, AM P. 13564; 1, JC 28; 2, JC 29; 1, JC 33; 2, JG 14-73; 4, QM W 1265; 1, WM 24-65; 2, WM 53-65; 2, WM 196-65; 1, WM 210-65.

DESCRIPTION: This species cannot be distinguished from the following *A. edwardsii* (Audouin) (p.404) except for three differences discussed below.

DISCUSSION: In 1972 we established a neotype for *A. edwardsii* and at that time we pointed our how Coutière had confused the characteristics of the species when he established *A. audouini* (1905a:911). Coutière in the same publication reduced *A. chiragricus* of Milne-Edwards to a varietal name under *A. edwardsii*. In our 1972 report we

*The spelling of this name with *i* or *ii* has been rather informal — thus De Man in 1911 used *A. Edwardsi* in most references, but in his discussions on pp.411, 416 and in his index, p.461, he used *A. Edwardsii*. We will refer to the species only as *A. edwardsii* in this discussion. See also footnote on p. 132.

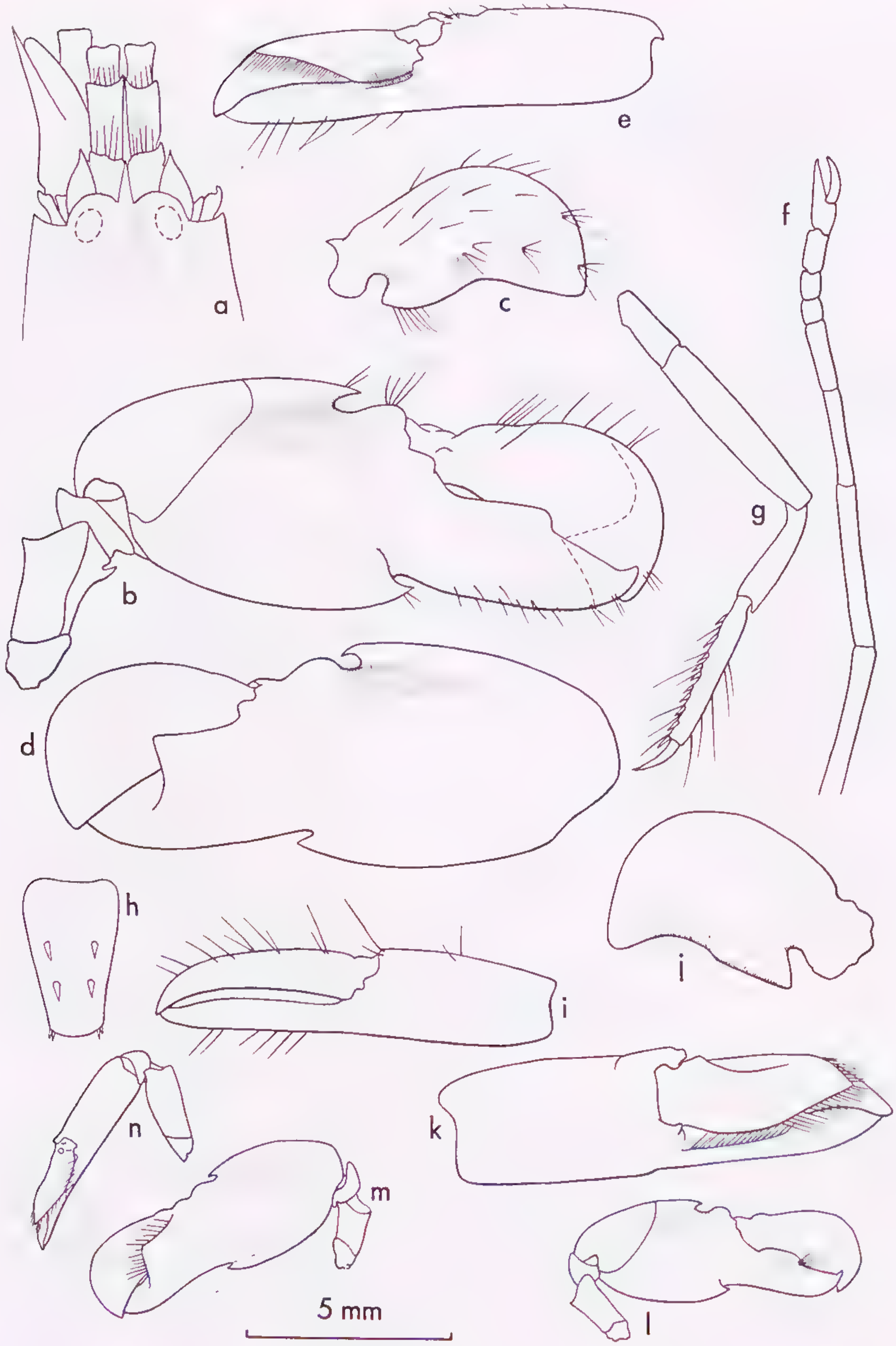

Fig. 82 *Alpheus chiragricus* Milne-Edwards
30 mm male from AM 42. **a.** Anterior region, dorsal view; **b, c.** large cheliped and dactylus, lateral face; **d.** large chela, medial face; **e.** small cheliped, medial face; **f.** second leg; **g.** third leg; **h.** telson. 28 mm female from AM 42. **i.** Small chela, medial face. *"Alpheus edwardsii"* Coutière, 1905a (*nec* Audouin) (= *A. chiragricus*) from Madras. **j.** Dactylus of large chela; **k.** small chela, lateral face. Drawings from photographs made by Dr Forest of Museum National d'Histoire Naturelle of Paris of the holotype of *A. chiragricus*. **l.** Large cheliped, lateral face; **m.** large cheliped, medial face; **n.** small cheliped, lateral face.
All figures except l, m and n same scale.

placed *A. audouini* in synonymy and again accepted, as De Man had in 1911, *A. chiragricus* as a valid species.

On the basis of 45 specimens of *A. chiragricus* and more than 100 specimens of *A. edwardsii*, all from Australia, and the neotypic series of *A. edwardsii* from the Suez, we believe that the following characteristics (listed in order of decreasing importance) will serve to separate *A. edwardsii* and *A. chiragricus:*

1. The development of the "shoulders" on the large chela. In *A. edwardsii* the shoulder proximal to the superior groove overhangs the groove but is obtuse; the inferior shoulder projects somewhat and is rounded (figs. 83 b, c). In *A. chiragricus* both shoulders project as acute, almost spiniform teeth (fig. 82b). This characteristic of *A. chiragricus* was initially confirmed by Dr Forest of the Muséum national d'Historie naturelle of Paris who kindly sent us photographs of the large and small chela of the holotype of *A. chiragricus* which are reproduced as the drawings in Figures 82 l, m, n; subsequently we have examined the holotype ourselves.

2. The proportions of the large chela: If the shoulder proximal to the superior saddle or groove is taken as the dividing point of the chela then in *A. edwardsii* the portions proximal and distal to this point are approximately equal in length, while in *A. chiragricus* the distal portion is usually 1.3-1.4 times the length of the proximal.

3. The shape of the rostrum: In *A. edwardsii* the rostrum is broader, being 1.4-2.0 times as long as broad at the base, while in *A. chiragricus* it runs from 2.0 to 3.0 times as long as broad. While the characteristics cannot be quantified, the rostral carina is round and the orbitorostral grooves are shallow and rounded in *A. edwardsii* with the grooves usually disappearing at the base of the eyes, while in *A. chiragricus* the carina is more abrupt and sharper, the grooves more narrow and deep, and they extend further posteriorly.

Coutière made several mistakes in 1905 when he attempted to separate these two species into three forms. He had evidently decided from Savigny's figures of the species that Audouin was to name *A. edwardsii*, that the outstanding characteristic was a slender rostrum. He found a specimen in the museum, collected by Henderson from Madras, that corresponded *"très exactement"* to this form. This specimen he therefore took to be representative of *A. edwardsii* and figured its large chela with spinose shoulders as typical of the species (figures 50a, 50a' and 50a"). As the *A. chiragricus* of Milne-Edwards had similar shoulders, he demoted that species to a varietal name, *A. edwardsii chiragricus;* while he did not distinguish between the two forms in his text, to judge from his figures (figs. 50, 51) he was atempting to separate them on the basis of the narrowness of the rostrum. In our interpretation of Savigny's figures the rostrum is broad and the shoulders of the chelae are not spinose, and these features certainly characterize our neotype of *A. edwardsii*. Therefore, Coutière's *A. edwardsii* is what we accept as *A. chiragricus*, and the apparent difference in rostral form between his *"A. Edwardsi"* and his *"A. Edwardsi chiragricus"* falls within the range of rostral variation we have found in our Australian specimens of *A. chiragricus*. As previously pointed out, the form he described as *A. audouini* is actually *A. edwardsii* as we redescribed it.

Two further minor corrections to Coutière's work: First, Audouin placed the species *edwardsii* in the genus *Athanas*, not *Athanasus* (Coutière, 1899:10, and 1905a:911). Second, neither *A. edwardsii* nor *A. chiragricus* reach from *"Nlle Zeland aux iles Sandwich"* (=Hawaiian Islands).

The specimens discussed by De Man in 1911 as *A. chiragricus* appear to be correctly identified, and his specimens of *A. audouini* are likely to be *A. edwardsii*.

BIOLOGICAL NOTES: This species has been collected under rocks intertidally and has been dredged as deep as 11 fathoms. It has been collected in heads of dead coral. It has also been found in the fouling growth on navigational buoys. Yaldwyn reported that a specimen from the Gulf of Carpentaria was found in a "cow-udder sponge" and another specimen from Townsville was reported as living in association with a giant anemone (JC-28). Our specimens range in size from 10-50 mm.

AUSTRALIAN DISTRIBUTION: In western Australia it was collected from Cockburn Sound, Port Hedland, Broome and off Cape Jaubert; in northern Australia from Darwin and the Gulf of Capentaria; and in eastern Australia from the Coral Sea to Port Curtis, Qld.

GENERAL DISTRIBUTION: *"Mers d'Asie"* (M-Ed), Indonesia, Mergui Archipelago.

Alpheus edwardsii (Audouin)*
Fig. 83

(Without name) Savigny, 1809, pl. 10, fig. 1.

Athanas Edwardsii Audouin, 1827:274.

Alpheus edwardsii Guérin Menéville, 1829-44, 2:pl. 21, fig. 5, 3:15. Miers, 1874:4, pl. 4, fig. 3. (*A. neptunus* on plate).

Alpheus audouini Coutière, 1905a:911, fig. 52.

Alpheus edwardsi Banner and Banner, 1973:1142, 1 fig. (Neotype established).

Nec A. edwardsii Bate, 1888:542, pl. 97, fig. 1 (=*A. leviusculus* Dana).

Previous Australian records**

Miers, 1874:4. Port Essington; 1884:285. Port Curtis, Port Molle, Port Dennison, Thursday Is., Darwin and Rockhampton.
Haswell, 1882b:188. Port Essington.
Kingsley, 1882:120 Port Essington.
Etheridge, 1889:35.
Whitelegge, 1889:224.
Ortmann, 1894:13. Thursday Is.
Grant and McCulloch, 1907:156. Norfolk Is.
Rathbun, 1914:654. Monte Bello Is. (as *Crangon edwardsii*).
Balss, 1921:9. Cape Jaubert.
McNeill, 1926:302. Queensland; 1937;263. Middleton Reef.
Hale, 1927b:308. Kangaroo Is.; 1929:68. Dirk Hartog Is. (as *C. edwardsi*).
Pope, 1949:327. Darwin. (as *C. edwardsii*).
Stephenson, Endean and Bennett, 1958:268. Low Isles.
Gillett, McNeill, 1959:123. (Sound production).

SPECIMENS EXAMINED: 1 specimen from AM 9 (AM P. 27824); 3, AM 13 (AM P. 27555); 1, AM 27 (AM P. 27837); 2, AM 28 (AM P. 27550); 2, AM 33 (AM P. 27813); 1, AM 40 (AM P. 27814); 1, AM 57 (AM P. 27830); 2, AM 60 (AM P. 27836); 1, AM 62 (AM P. 27919); 2, AM 79 (AM P. 27561); 4, AM 102 (AM P. 27529); 1, AM 113 (AM P. 27462); 2, AM 129 (AM P. 27838); 5, AM 150 (AM P. 27839); 1, AM 154 (AM P. 27531); 1, AM 160 (AM P. 27799); 1, AM 169 (AM P. 27532); 1, AM 180 (AM P. 27549); 1, AM 183 (AM P. 27533); 1, AM 184 (AM P.

*For explanation of spelling see footnote, p. 132.

**The correctness of the identifications listed below is questionable, as we pointed out in our 1972 paper. However, we were able to examine some specimens of *A. edwardsii* from Monte Bello Is. at the British Museum (Natural History) which were correctly identified.

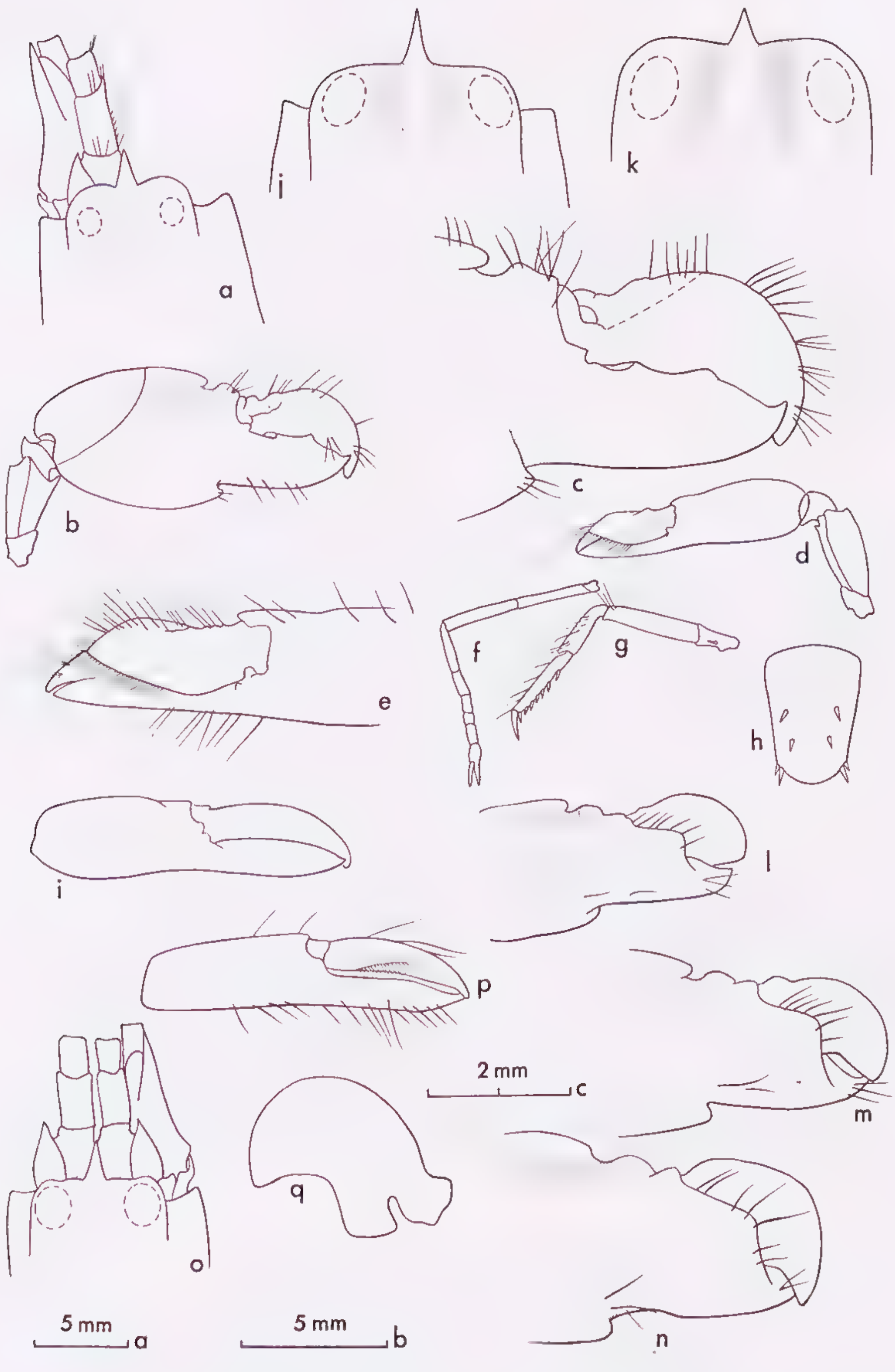

Fig. 83 *Alpheus edwardsii* (Audouin)
32 mm male from AM 217. **a.** Anterior region, dorsal view; **b, c.** large cheliped and enlargement of distal region, lateral face; **d, e.** small cheliped and enlargement of distal region, lateral face; **f.** second leg; **g.** third leg; **h.** telson. 30 mm female from AM 217. **i.** Small chela, lateral view. 27 mm male from AM P. 2577. **j.** Anterior region, dorsal view. 30 mm female from AM P. 6355. **k.** Anterior region, dorsal view. Three neoparatypic specimens from the Suez Canal. **l, m, n.** Distal region of large chelipeds (after B & B, 1972: figs. l, e, m and n). 15 mm female from JG 12-73. **o.** Anterior region, dorsal view; **p.** small chela, lateral view; **q.** dactylus, large chela. b, d, f, g, l, m, n scale a; a, c, e, h, i, q scale b; j, k, o, p scale c.

27920); 1, AM 188 (AM P. 27534); 4, AM 190 (AM P. 27815); 1, AM 200 (AM P. 27817); 2, AM 208 (AM P. 27816); 2, AM 217 (AM P. 27840); 1, AM 242 (AM P. 27850); 1, AM 254 (AM P. 27851); 1, AM 265 (AM P. 27796); 3, AM 280 (AM P. 27459); 11, AM 281 (AM P. 28104); 4, AM 285 (AM P. 27797); 1, AM 292 (AM P. 27807); 1, AM 300 (AM P. 27458); 1, AM 301 (AM P. 27803); 1, AM 308a (AM P. 27554); 1, AM 309 (AM P. 27455); 1, AM 312 (AM P. 27544); 1, AM 382 (AM P. 27835); 1, AM 422 (AM P. 27852); 1, AM 448 (AM P. 27565); 1, AM G. 5782; 4, AM P. 1418; 3, AM P. 6354; 2, AM P. 6355; 4, AM P. 6605; 1, AM P. 7902; 2, AM P. 9481; 2, AM P. 11730; 2, AM P. 11779; 3, AM P. 11882; 8, AM P. 27430; 1, AM P. 27789; 1, AM P. 28164; 9, BAU 6; 2, BAU 10; 1, BAU 20; 2, BAU 36; 2, BAU 40; 1, BAU 43; 5, BAU 50; 1, BAU 72; 19, BAU 73; 1, CS 37; 1, CS 40; 2, JB 1; 1, JC 5; 1, JC 6; 2, JC 7; 4, JC 11; 1, JG 7-73; 1, JG 12-73; 3, JG 16-73; 5, QM W 1265; 2, QM W 1296; 1, UQ 3; 1, UQ 5; 1, UQ 7; 1, UQ 10; 1, UQ 14; 2, UQ 21; 2, UQ 24; 1, UQ 25; 1, US 123590; 2, VM 19; 1, WM 42-65; 1, WM 48-65; 2, WM 53-65; 1, WM 60-65; 1, WM 98-65; 1, WM 106-65; 1, WM 161-65; 1, WM 165-65; 1, WM 167-65; 2, WM 168-65; 1, WM 169-65; 2, WM 170-65; 1, WM 179-65; 2, WM 191-65; 1, WM 210-65; 7, WM 243-65; 5, WM 251-65; 1, WM 252-65; 2, WM 278-65; 2, WM 279-65; 4, WM 286-65; 1, WM 10876.

DIAGNOSIS: Following is the description of the neotype (Banner and Banner, 1972:1142); "Rostrum 1.4 times as long as wide at base, reaching to near end of first antennular article. Broad, moderately deep orbitorostral gooves disappearing at posterior margin of orbits. Visible part of first antennular article 0.8 as long as second antennular article which is 2 times as long as broad; third antennular article 0.5 as long as second. Stylocerite acute, reaching to end of first antennular article. Scaphocerite with squamous portion reaching nearly to end of third antennular article, lateral tooth a little longer. Carpocerite reaching well past end of third article. Lateral tooth of basicerite small, acute.

"Large chela 2.3 times as long as broad, fingers occupying 0.3 total length. Superior margin bearing transverse groove proximal to dactylus. Proximal edge of groove obtuse, never acute, overhanging floor of groove; distal margin of groove rounded; groove continued on inner face as poorly defined triangular depressed area, the apex of which reaches to proximal quarter of chela; groove continued on outer face as well defined quadrangular depression, proximal portion reaching *linea impressa* and inferiorly extending 0.3 width of palm. Deep notch on inferior margin directly opposite superior groove, demarked proximally by heavy shoulder with tip slightly projected but not acute; distal margin of groove rounded. Inferior groove extends as a slightly depressed triangular area only 0.2 into outer face of palm. Merus 2 times as long as broad, bearing an acute tooth distally on inferointernal margin; superior and inferoexternal margins not projecting.

"Small chela sexually dimorphic. Male chela 3.8 times as long as broad with fingers 0.6 as long as palm. Superior margin of palm bearing small groove proximal to dactylus that is extended slightly into outer face; inferior margin with only slight trace of concavity comparable to groove and shoulder of large chela. Dactylus proximally broadened into a triangular area demarked by fringes of short stiff setae which line margins near articulation of dactyl and curve to meet on superior surface proximal to tip; this is the usual "balaeniceps" development, Female chela 4.4 times as long as broad with fingers and palm almost equal. Chela with traces of large chela sculpturing, but even less developed than male, and without fringe of setae on dactyl. Meri of both male and female small chelipeds similar, 2.2 times as long as broad and bearing an acute tooth distally on inferointernal margin. External and superior margins not projecting distally.

"Carpal articles of second leg with ratio: 10:6:3:3:5.

"Ischium of third leg bearing strong spine. Merus of third leg 5 times as long as broad, inermous. Carpus 0.5 as long as merus, superodistal margin projecting into a tooth. Propodus almost 0.8 as long as merus, bearing 6 inferior spines and 2 distal spines. Dactylus simple and slightly curved, 0.3 as long as propodus.

"Telson 2 times as long as posterior margin is broad; spines on dorsal surface small; outer pair of terminal spines as long as dorsal spines, inner spines a little longer".

DISCUSSION: In 1972 we used a number of Australian specimens to determine the extent of the range in the characters of *A. edwardsii*. We repeat our findings here:

"1. The rostrum varied from 1.4-2.0 times as long as broad at the base.

"2. The ratio of the first and second article of the antennular peduncles varied from 10;13-10:16; the ratio of the visible part of the first to third antennular article varied from 10:6-10:10.

"3. (The shoulders proximal to both the superior and inferior grooves of the large chela were found to vary independently from right angles, with rounded edges, to blunt rounded projections (illustrated but not described in original discussion).)

"4. The small chela varied in males from 3.4-4.4, and in the females from 3.8-5.4 times as long as broad.

"5. The first two carpal articles of the second leg varied from 10:5-10:8.

"6. The merus of the third leg varied from 4.3-5.3 times as long as broad."

We have a 15 mm female specimen from Moreton Bay (JG 12-73, see fig. 83p) in which the dactylus of the small chela has a slight fringe of hair on the lateral and medial face instead of being totally lacking. This condition in the females of species of the Edwardsii Group with sexually dimorphic small chelae has been noted before (Banner and Banner, 1966a:185). In addition, in this specimen the orbitorostral margin is straight rather than concave. As in all other characteristics this specimen easily falls within the range of variation we have found for this species, we are treating it as another variation.

We have examined the holotype and sole specimen of *A. minor* de Haan at the Rijksmuseum van Natuurlijke Historie, Leiden, which is a female; as the name was preoccupied, the species was renamed *A. haanii* by Ortmann (1890:472). In all characteristics this specimen falls within the ranges we have found for *A. edwardsii*, but the synonymy cannot be confirmed until the small chela of a male is examined. We suggest that when specimens are obtained from Nagasaki, Japan, the probable type locality of *A. haanii* (see Banner and Banner, 1974:431), the question of possible synonymy be resolved. We also wish to report that the figures given for *A. haanii* by Yokoya (1939:266) do not compare well with the holotype, and that the slender large chela and the acute overhanging shoulder on its superior and inferior margins are similar to *A. japonicus* Miers.

BIOLOGICAL NOTES: This species is largely intertidal, living under rocks in sandy, muddy conditions. It has been dredged from as deep as 14 fathoms and has been collected on navigational buoys and beacons. One specimen was reported from a clump of live coral, but probably it was taken from the dead part near the base. We have specimens ranging in size up to 40 mm.

AUSTRALIAN DISTRIBUTION: Specimens that we have examined have been collected on all the coasts of Australia.

GENERAL DISTRIBUTION: As pointed out in our 1972 paper this binomen has been so confused in its use that we cannot trace out the distribution of the species in the Indo-Pacific. On the basis of our collections we can report it from the Red Sea, Australia, Thailand and the Philippines. It probably extends widely through the Indian Ocean, into

Southeast Asia, but it is not known on the islands of the Central Pacific nor from New Zealand.

Alpheus polyxo De Man
Fig. 84

Alpheus polyxo De Man, 1909a:108; 1911:423, fig. 104.

SPECIMENS EXAMINED: 1 specimen from AM 91 (AM P. 27517); 1, AM 118 (AM P. 27558); 2, AM 143 (AM P. 27570); 1, AM 165 (AM P. 27562); 2, AM 186 (Am P. 27328); 1, AM 257 (AM P. 27522); 2, AM 280 (AM P. 28165); 1, AM 309 (AM P. 27454); 1, AM 409 (AM P. 28166); 2, AM 410 (AM P. 27523); 1, AM P. 3544; 1, AM P. 27435; 1, AM P. 27439; 3, AM P. 27790; 3, AM P. 27791; 1, AM P. 28124; 1, BAU 28; 3, BAU 37; 2, BAU 38, 1, BAU 40; 2, BAU 44; 2, BAU 47; 5, BAU 48; 2, BAU 50; 2, BAU 53; 1, BAU 58; 1, UQ 11; 1, WM 79-65; 1, WM 91-65; 1, WM 186-65; 1, WM 189-65; 4, WM 274-65.

DIAGNOSIS: Rostrum 1.8 times as long as wide at its base, reaching to end of first antennular article, bearing a marked but rounded carina reaching from tip posteriorly to well behind eyes and bearing a number of upstanding hairs. Margins of orbital hoods rounded laterally, medially extending as flattened prominences. Second antennular article 2.5 times as long as broad, 1.8 times longer than visible part of first, 2.0 length of third. Antennular articles bearing on distal margins as well as superior surface a small number of long hairs. Stylocerite reaching slightly beyond end of first antennular article. Scaphocerite with outer margins concave, squamous portion narrow, lateral spine reaching to end of carpocerite and beyond squame by 0.6 length of third antennular article.Carpocerite slender, 6 times as long as wide, reaching just beyond end of antennular peduncle.

Large chela heavy, 2.1 times as long as broad, fingers occupying distal 0.35. Superior saddle deep, somewhat narrow, proximal shoulder rounded and overhanging saddle, distal shoulder prominent, gradually rounded. Lateral palmar depression well defined, quadrangular, extending to *linea impressa*. Medial palmar depression well defined, triangular, reaching proximally to middle of palm. Inferior shoulder rounded, only moderately heavy, not extended. Inferior notch shallow. Inferolateral depression shallow, extending as a shallow "U"-shaped groove that reaches to middle of palm, with rounded apex directed proximally. Inferomedial depression lacking. Plunger of dactylus low and confluent with distal margin. Merus 2.3 times as long as broad, bearing on its inferodistal margin a small sharp tooth, superodistal margin slightly projected.

Small chela sexually dimorphic with dactylus balaeniceps in males only. Male chela 3.7 times as long as broad with fingers 0.4 total length. Superior margin bearing a slight transverse groove proximal to dactylus. Merus 2.1 times as long as broad with small acute tooth terminally on inferointernal margin. Female chela 4.0 times as long as broad, fingers as long as palm, tapering. Palm bearing a slight depression proximal to dactylus.

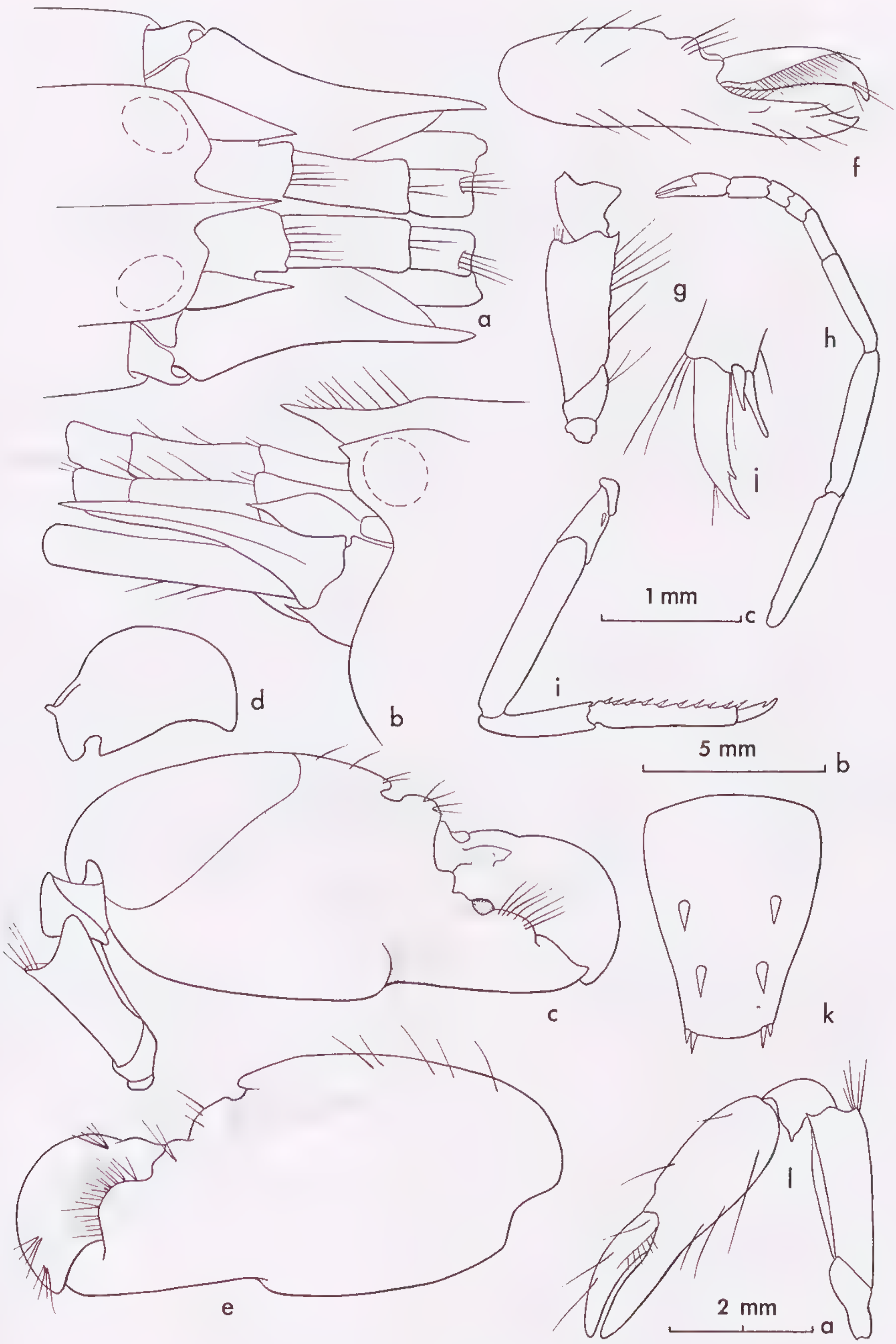

Fig. 84 *Alpheus polyxo* De Man
32 mm male from AM 280. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large cheliped and dactylus, lateral face; **e.** large chela, medial face; **f, g.** small chela, merus and carpus, medial face; **h.** second leg; **i, j.** third leg and enlarged dactylus; **k.** telson. 32 mm female from AM 280. **l.** Small cheliped, medial face. a, b, k scale a; c, d, e, f, g, h, i, l scale b; j scale c.

Dactylus bearing short fringes of setae only on proximal portion of margins. In some specimens, fringe of setae lacking on one or both faces of dactylus. Carpus cup shaped bearing a sharp tooth distally near inferior margin of palm.

Ratio of carpal articles of second leg: 10:5:2:2:4.

Ischium of third leg with small spine. Merus 5 times as long as broad, inermous. Carpus 0.5 as long as merus, inferodistal margin bluntly produced. Propodus 0.8 as long as merus, carrying about 10 spines on inferior margin. Dactylus 0.3 as long as propodus, slightly curved, and biunguiculate with inferior unguis less than 0.3 length of superior and located one-quarter length of dactylus from tip.

Telson 2.3 times as long as posterior margin is broad, anterior margin 1.8 times wider than posterior margin. Posterior margin evenly rounded.

DISCUSSION: We have examined the male holotype and female allotype of *A. polyxo* at the Zoologisch Museum in Amsterdam. De Man mentioned the rounded prominences of the inner margins of the orbital hoods but his figure 104 does not show them; they are on the types. Also, while he mentioned the secondary unguis on the dactylus of the third leg his figure 104e does not show it; the types also have this structure. He stated that the dactylus of the small chela of the male bore a fringe of setae on the inner face, but that the outer face was glabrous. This is true of the holotype. The small chela of the female is lacking as are the large chelipeds for both specimens.

We find our specimens agree well with De Man's with two notable exceptions. In most of the males in our collection the fringes of setae on the dactylus are on both faces and extend to the superior surface, the typical balaeniceps condition. However, there are a few in which the fringes of setae are much reduced, similar to De Man's. This does appear to be somewhat related to size as we find the specimens with the reduced fringes of setae are smaller than 25 mm. However, we have a male specimen of 18 mm in length that is fully balaeniceps. De Man's male was 22 mm in length. The second exception is that all of our specimens carried several upstanding hairs on the rostral carina as well as the distal margins of the antennular articles (e.g. fig 84b). De Man's specimens carry the long hairs on the antennular articles, but the carina is glabrous.

These two characteristics may be of subspecific worth in separation of the Australian form from De Man's Indonesian form, but until more specimens and complete specimens are collected from the type locality the separation would be questionable.

BIOLOGICAL NOTES: Specimens we collected personally came from dead coral in water up to 10 ft. deep; others were dredged as deep as 71 fathoms. The specimens ranged in size from 12-35 mm.

AUSTRALIAN DISTRIBUTION: In western Australia the specimens were collected between Shark Bay and Bedout Is; in northern Australia from Thursday Is., and in eastern Australia between Cairns and Stradbroke Is., Qld.

GENERAL DISTRIBUTION: This is the first time this species has been reported since De Man described it from Banda in Indonesia.

Alpheus pareuchirus pareuchirus Coutière Subspec. designated
Fig. 85a-k

Alpheus pareuchirus Coutière, 1905a:906, pl. 84, fig. 43. De Man, 1911:418, fig. 101.

Alpheus pareuchirus var. leucothea De Man, 1911:420, fig. 102.

SPECIMENS EXAMINED: 1 specimen from AM E. 3190; 1, AM P. 28137; 1, QM W2249; 2, WM 275-65.

DIAGNOSIS: Rostrum slender, 2 times as long as wide at base, acute, reaching slightly past middle of first antennular article. Visible part of first antennular article a little longer than third; second article almost twice as long as broad and 1.6 times longer than third article. Stylocerite reaching to end of first antennular article. Lateral spine of scaphocerite as long as carpocerite and antennular peduncle; squamous portion of scaphocerite a little shorter. Basicerite with acute lateral tooth.

Large chela 2.4 times as long as broad, fingers occupying the distal 0.4. Superior saddle well developed; proximal shoulder projecting above saddle but rounded; distal shoulder rounded. Lateral palmar depression almost triangular with rounded proximal apex lying almost in proximal third of palm; medial palmar depression narrow and acutely triangular, slightly longer than lateral depression. Medial face with a narrow longitudinal groove near inferior margin that extends proximally from near articulation of carpus to inferior notch. Inferior notch slight, not continued into faces of palm as depressions; inferior shoulder low and rounded. Plunger of minimal development. Merus a little longer than broad, bearing strong acute tooth distally on inferointernal margin.

Small chela sexually dimorphic. Chela of male 3.7 times as long as broad, with fingers only slightly shorter than palm and with dactylus of typical balaeniceps development, laterally expanded with crests of hairs meeting on superior surface proximal to tip; proximal half of both margins of pollex with crests of hair. Palm with marked superior saddle, with proximal shoulder slightly overhanging groove and with medial and lateral palmar depressions long and triangular. Merus 2.0 times as long as broad, bearing distally on inferointernal margin a small acute tooth. Female chela simple, 3.6 times as long as broad, with simple conical fingers almost equal in length to palm; palm without sculpturing, 2.4 times as long as broad. Merus similar to that of male, but more slender, 4.0 times as long as broad (as we lacked a female with a small chela Fig. 85k is a female from the Siboga Expedition, St. No. 51).

Carpal articles of second legs with ratio: 10:9:3:3:5.

Ischium of third leg with strong spine. Merus inermous, 6.5 times as long as broad. Carpus 0.5 as long as merus, distal angles slightly projecting. Propodus 0.8 as long as merus, bearing on its inferior margin 10-12 small spines and a pair distally. Dactylus simple, 0.4 as long as propodus.

Telson 2.5 times as long as broad posteriorly. Anterior pair of dorsal spines definitely anterior to middle. Inner spines of posterolateral pair of little more than twice length of outer.

DISCUSSION: The inferior shoulder of the large chela in our specimens is distinct but rounded while in both Coutière's and De Man's specimens it is less pronouned and the margin merely appears to be sinuous. We have examined the type series from Hulule Male Atoll at the Muséum National d'Histoire Naturelle in Paris (there are 3 males and 2 ovigerous females). Of the five specimens all lack the small cheliped and there are only 3 large chelipeds lying loose in the vial. In one of the chela the inferior margin which Coutière described as *"Simplement sineux"* has a more abrupt inferior shoulder than the one figured (1905a:fig. 43a). This appears to be a variable character that may be influenced by size of the specimen.

The merus of the third leg was described by Coutière as being 7 times as long as

broad; this is slightly more slender than in our specimens, but De Man, with a larger number of specimens at hand, pointed out that the third legs in the larger specimens were heavier. The inferodistal margin of the merus in Coutière's type was angular while in our specimens it is rounded; this also appears to be a variable characteristic. De Man remarked that Pearson's specimen from Ceylon (1905:86) probably was not *A. pareuchirus;* this appears likely since the merus of the large chela bore no tooth on the inferointernal margin, distally.

De Man described a variety from his Siboga material which he called *A. p. leucothea*. For comparison with our specimens, the Zoologisch Museum of Amsterdam loaned us 18 specimens of *A. p. pareuchirus* and 3 specimens of *A. p. leucothea* from the Siboga material which De Man himself had identified. De Man separated his variety *leucothea* on the basis of 3 characters.

1. In *A. p. pareuchirus* the proximal margin of the superior groove of the large chela markedly overhangs the floor of the groove while in *A. p. leucothea* it does not. We found this to be variable both in the Siboga specimens and in ours. The proximal margin varies from right angles to the floor of the groove to overhanging the groove. This does not appear to be a reliable character.

2. In the typical *A. p. pareuchirus*, according to Coutière, the merus of the third leg *"A son apex inférieur distal il se termine par un bord nettement aigu, mais non épineux..."* while in *A. p. leucothea*, according to De Man, the distoinferior margin is rounded. We found this character subject to variation. It is true in some of the Siboga specimens the distoinferior margin was sharp, but in others it was rounded; in our specimens all were rounded. Again this does not appear to be a well-defined difference.

3. In *A. p. pareuchirus* the merus of the third leg is more slender, varying from 6-7 times as long as broad while in *A. p. leucothea* De Man states it is "around 5.3 times as long as broad". In two of our specimens the merus is 5 times as long as broad, and in another 6.3 and in 2 others 6.5. One of the specimens did not have any third legs. From our experience with the Edwardsii Group this range of variation is to be expected.

Thus the slight differences that are supposed to separate the variety from the nominate species appears to be within the normal range of variation and we are placing the variety into synonymy.

The variety *A. p. imitatrix* (De Man, 1911:426) in which both the male and female bear the balaeniceps dactyli on the small chela (see fig. 85l) appears to be valid and we are raising it to subspecific rank (see following).

BIOLOGICAL NOTES: All specimens of this subspecies reported so far have been dredged from at least 15 metres deep except the several specimens in our own collections from the Philippines which came from no more than 10 ft. deep. The specimens range in size up to 30 mm.

AUSTRALIAN DISTRIBUTION: Three specimens were collected near Percy Isles, S. E. Qld., and 2 from Port Hedland in Western Australia.

GENERAL DISTRIBUTION: Madagascar; Maldives; Indonesia; Philippines.

Alpheus pareuchirus imitatrix De Man
Fig. 85 l

Alpheus pareuchirus var. imitatrix De Man, 1909a:106; 1911:426.

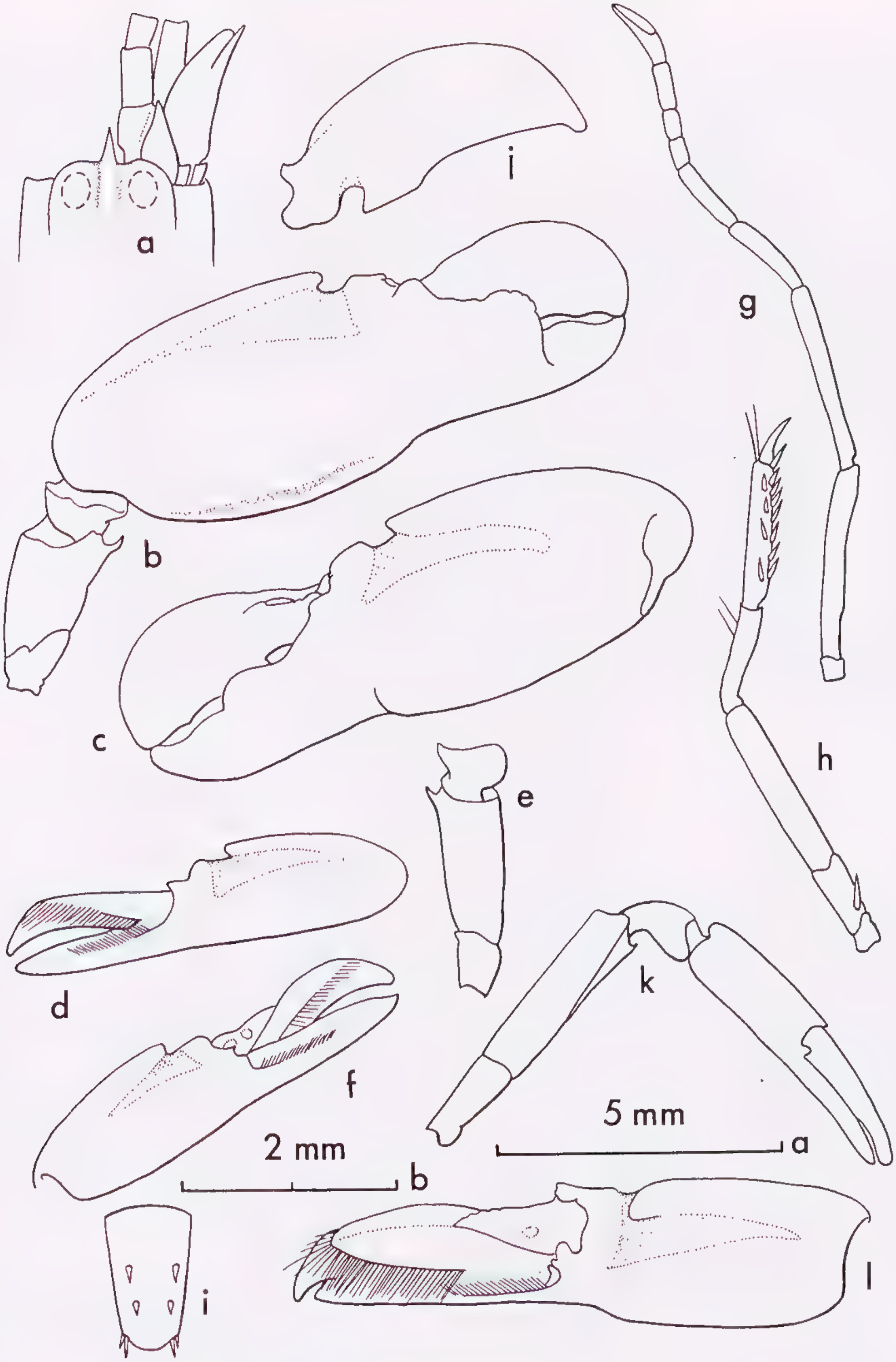

Fig. 85 *Alpheus pareuchirus pareuchirus* Coutière
24 mm male from AM E. 3190. **a.** Anterior region, dorsal view; **b, c.** large cheliped, medial face and chela, lateral face; **d, e.** small chela and merus, medial face; **f.** small chela, lateral face; **g.** second leg; **h.** third leg; **i.** telson. 30 mm male from WM 275-65. **J.** Dactylus of large chela. 18 mm female from Siboga station No. 51. **k.** Small cheliped, lateral face.

Alpheus pareuchirus imitatrix De Man
30 mm female from AM 280. **1.** Small chela, lateral face. a, b, c, d, e, f, g, h, i, j, l scale a; k scale b.

SPECIMENS EXAMINED: 1 specimen from AM 160 (AM P. 28138); 1, AM 280 (AM P. 28139); 1, MM 434.

DIAGNOSIS: See *A. p. pareuchirus* Coutière preceding for diagnosis except for the small chela of the female.

DISCUSSION: *A. pareuchirus var. imitatrix* was separated from the nominate subspecies only by the development of a balaeniceps dactylus on the small chela of the female. Two of our female specimens (AM 160 and AM 280) resemble the nominate species exactly except for the small chela which is the same as the male. The grooving on the palm is quite similar except the inferior shoulder is more pronounced (see fig. 85l). The merus of the third legs of the 3 specimens (including MM 434) was 5.0 times as long as broad, a little heavier than the nominate subspecies. The specimen from Torres Straits (MM 434) is questionable as it lacks the small cheliped, but as stated above the merus of the third leg was stout, typical of the subspecies *imitatrix*.

BIOLOGICAL NOTES: One of the specimens came from the growth on a pearl oyster shell and another was dredged at 12 fathoms. De Man's specimens were dredged as deep as 141 metres. Our specimens reached up to 30 mm in length.

AUSTRALIAN DISTRIBUTION: One specimen came from Van Diemans Gulf, near Darwin, and one was from the Torres Straits; the third was dredged off Port Curtis, Qld.

GENERAL DISTRIBUTION: De Man's specimens came from Indonesia and this is only the second report of collection of the subspecies.

Genus **Metalpheus** Coutière

Alpheus sp. ? *Metalpheus* n. gen. Coutière, 1908a:213, 1921:419, pl. 62, fig. 15.

Metalpheus Chace, 1972:78

TYPE SPECIES: *Alpheus rostratipes* Pocock

DIAGNOSIS: General body form similar to *Alpheus,* eyes normally covered by orbital hoods but may be exposed through rough handling.

Antennular peduncle short and relatively heavy. Basicerite and carpocerite of antennal peduncles also massive; squame may be reduced.

Labrum enlarged and protruding. Incisor process of mandible expanded and enclosing labrum; margin with numerous teeth. Epipodite of second maxilliped a soft-walled triangular lobe. Basal article of endopod of third maxilliped flattened in section, not trigonal , mediolaterally expanded and curving to enclose more anterior mouthparts; basal article longer than sum of following two.

First chelipeds like *Alpheus,* with both large and small chelipeds varying in form with sex and maturity; large chela with at most slight to moderate sculpturing. Second legs may be short and massive; carpus of 5 articles. Third to fifth legs with propodi somewhat curved, dactyli biunguiculate.

Appendix masculina of endopod of second male pleopod greatly elongate, reaching beyond tips of both rami. Third to fifth pleopods of females with *appendix interna* large and arising in distal third of endopod, with tip reaching to end or near end of that ramus.

Distal articulation of outer branch of uropods not straight but curving to form several lobes. Inner branch bearing spines on distolateral margin. Telson similar to *Alpheus,* with anal tubercles.

Branchial formula including 5 pleurobranchs, 1 arthrobranch and epipodites, usually with the last mastigobranch on the third legs and the last setobranch on the fourth.

DISCUSSION: This genus, now containing three or possibly four species (see below), has a somewhat confused history. In 1908 Coutière described two specimens from the Percy Sladen Trust Expedition to the Indian Ocean (exact locality not specified; description repeated with figures in 1921). He suggested that they might or might not be of the same species as Pocock described in 1890 as *Alpheus rostratipes* from Fernando de Noronha in the Atlantic. He also suggested that these one or two species might constitute a separate genus for which he advanced (with a question mark) the name *Metalpheus*. As only one chela was present in both his and Pocock's specimens, Coutière deferred final decision on the validity of the new genus until both chelae had been studied from both oceans.

As pointed out by Chace (1972:78), Shelford (1909:2631) listed the genus in the *Zoological Record* and designated *A. rostratipes* as the type species.

The species, now recognized as *M. rostratipes,* thereafter appeared in the literature under a confusing series of names (see synonymy under that species p. 429) and was finally and definitely established with complete synonymy in the work of Crosnier and Forest (1966:246); however, those authors retained it in the genus *Alpheus*. Only in 1972 was the generic name *Metalpheus* revived by Chace *(loc. cit.)* for this species and for *Alpheus paragracilis* Coutière. In 1974 (p. 424) we re-examined the holotype of *Alpheus hawaiiensis* (Edmondson) and found it, too, met the criteria established by Chace.

There may be a fourth species in this genus. In 1900 Borradaile (p. 417) described *Alpheus aglaopheniae* on the basis of a single incomplete female specimen "found living in the branches of a hydroid polyp of the genus *Aglaophenia*" from the "Engineer Group, British New Guinea". Through the courtesy of the University Museum of Zoology at Cambridge, England, we were able to examine Borradaile's holotype. When described by Borradaile the specimen was incomplete; since then all of the pereiopods have ben lost. We found his illustrations to be accurate. On the basis of the protrudant mouthparts, the expanded proximal endopodal article of the third maxillipeds (we did not try to dissect the underlying mouth parts on this sole specimen), the heavy antennular and antennal peduncles and especially the highly modified pleopods, this species plainly belongs to the genus *Metalpheus*. There is nothing in the original description nor in the remains of the holotype that could be used to separate this species from Coutière's *M. paragracilis* named three years earlier. In spite of this, we have decided to let the species stand on the basis of its habitat, for neither *M. paragracilis* nor any other alpheid, for that matter, has been recorded as living in hydroid colonies. This may indicate a degree of specialization that could be reflected by its morphology if a complete specimen were available.

The genus is very close to *Alpheus* on one hand and to *Pomagnathus* Chace (1937:124) on the other. From *Alpheus* it is separated by the enlargement of the labrum, the expansion of the incisor process on the mandibles, the modification of the epipodite of the second maxillipeds, the somewhat opercular development of the proximal endopodal article of the third maxillipeds, and the modification of the pleopods in both the male and female. The loss of the last setobranch and mastigobranch normally found in *Alpheus* is also distinctive, although there may be variation in this character (B & B 1964:90). In quick examination the species of *Metalpheus* stand out from *Alpheus* in the relative heaviness of the antennular peduncles and the massive and protruding mouthparts. The nature of the articulation on the outer branch of the uropods has not been remarked upon before although it is plainly shown by Crosnier and Forest (1966: fig. 12f); however, as this articulation is not usually studied, we do not know how valid this

criterion may be to separate this from other genera.

The genus *Pomagnathus* Chace (1937:124) is yet more closely related, but Chace (1972:78) separates it as follows: "*Pomagnathus* agrees with *Metalpheus* in the form of the front and mouthparts (although the incisor process of the mandible is armed with longer and sharper teeth, and the antepenultimate segment of the third maxilliped is even more expanded than in *M. rostratipes*), but it differs in lacking epipods on all of the pereiopods and in having an appendix masculina that is even shorter than the appendix interna rather than abnormally elongate."

KEY TO THE KNOWN SPECIES OF THE GENUS METALPHEUS

(*M. aglaopheniae* not included; see discussion below)

1. Large chela with inferior shoulder abrupt; squamous portion of scaphocerite as long as, or longer than, antennular peduncle; second carpal article of second legs about twice as long as broad; merus of third leg with strong tooth .... *M. paragracilis* p. 282
2. Inferior shoulder of large chela represented by only a slight, rounded depression; squamous portion of scaphocerite reaching to near end of third antennular article; second carpal article about as broad as long; merus of third leg with rounded projection or slight tooth .... *M. hawaiiensis** p. 281
3. Inferior margin of large chela without trace of shoulder or depression; squame reaching slightly beyond end of second antennular article; second carpal article about as broad as long; merus of third leg distally rounded. . *M. rostratipes* p. 285

*Known only from Lisiansky Island, leeward Hawaiian chain.

Metalpheus paragracilis (Coutière)
Fig. 86

Alpheus paragracilis Coutière, 1897b:303; 1905a:883, pl. 76, fig. 22.
Metalpheus paragracilis Chace, 1972:78.
Crangon paragracilis Banner, 1953:96, fig. 33.

Previous Australian Records:
Coutière, 1900:404. Murray Island
O'Loughlin, 1969:37. Houtman Abrolhos.

SPECIMENS EXAMINED: 2 specimens from AC C-28; 3, AM 74 (AM P. 27504); 30, AM 109 (AM P. 27506); 1, AM 214 (AM P. 27560); 1, AM 339 (AM P. 27505); 2, BAU 21; 2, BAU 31; 1, BAU 32; 4, BAU 33; 2, BAU 48; 3, BAU 57; 2, BAU 58; 1, WM 62-65; 2, WM 225-65; 1, WM 235-65; 1, WM 209-57.

DIAGNOSIS: Rostrum acute, reaching to end of first antennular article; lateral margins with a few setae. Rostrum with slight rounded carina. Orbitorostral grooves shallow, extending only to base of eyes. Orbitorostral margin deeply indented. Margins of orbital hood subacute. Antennular articles nearly equal, second article as broad as long. Stylocerite acute, reaching to middle of second antennular article; outer margin of scaphocerite slightly concave, lateral tooth strong, reaching well past end of antennular peduncle, squamous portion reaching to end of third article. Carpocerite as long as lateral spine of scaphocerite. Basicerite heavy, with lateral tooth reaching almost to end of second antennular article.

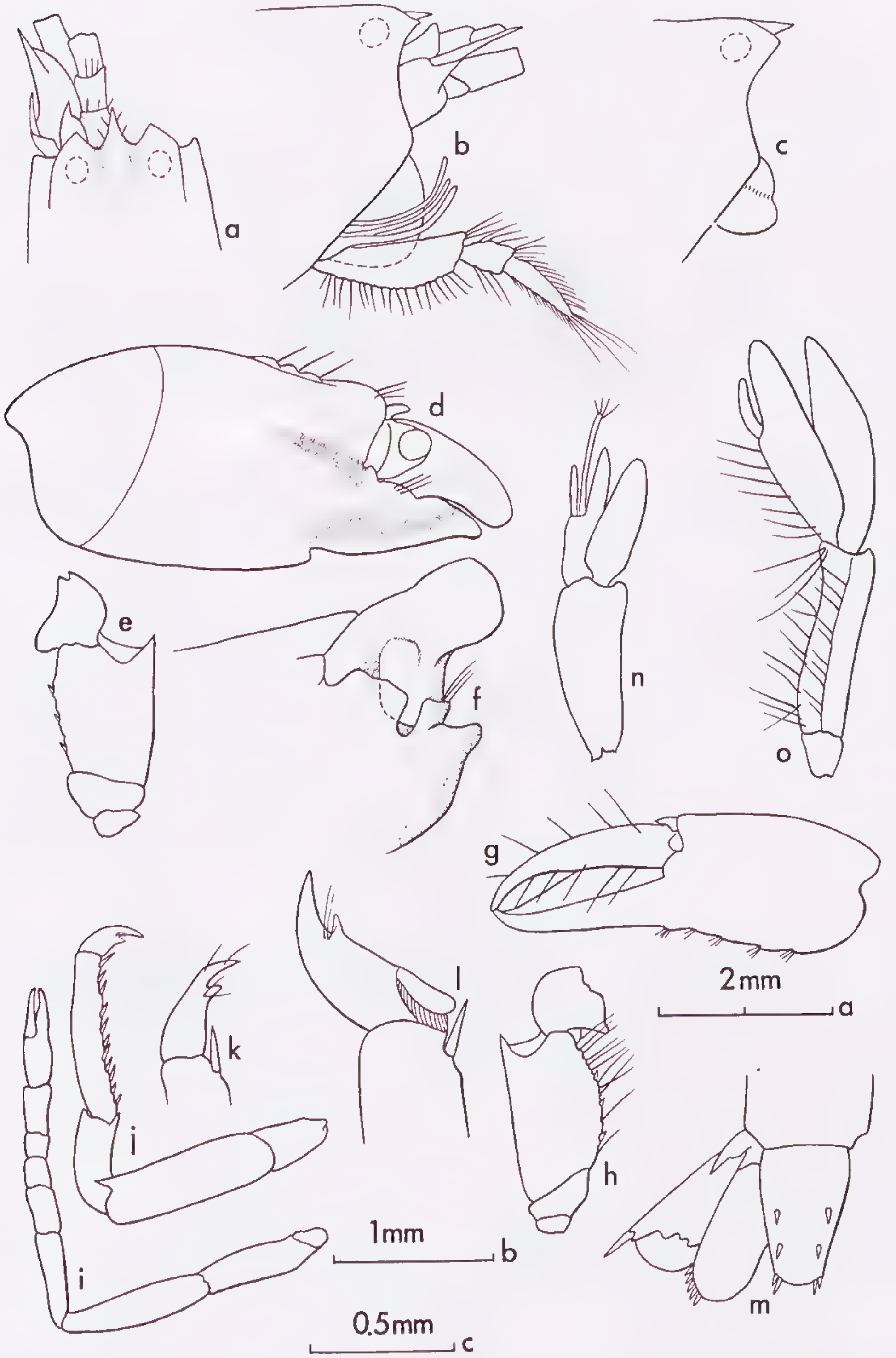

Fig. 86 *Metalpheus paragracilis* (Coutière)
14 mm male from BAU 58. **a, b.** Anterior region, dorsal and lateral view; **c.** anterior region of carapace showing labrum; **d, e.** large chela, lateral face and merus, medial face; **f.** large chela, distolateral face and detail of dactylus; **g, h.** small chela, lateral face and merus, medial face; **i.** second leg; **j, k.** third leg and dactylus enlarged; **l.** dactylus of third leg showing "heel" sclerite; **m.** telson and uropods; **n.** second pleopod. 14 mm female from BAU 58. **o.** Second pleopod. a, b, c, d, e, g, h, i, j, m scale a; f, k, n, o scale b; l scale c.

Mouthparts protrudant as normal in genus. Basal article of endopod of third maxilliped 3 times as long as wide in middle and 1.4 times length of two distal articles.

Large chela compressed, 2.3 times as long as broad, fingers occupying distal third; axis of fingers rotated about 30° to proximal portion of palm. Lateral face with 2 shallow grooves, one extending proximally from dactylar articulation, the other proximally from distal third of propodal finger; both reaching near level of inferior shoulder on palm. Inferior shoulder abrupt; groove from inferior notch confluent with lower groove. Medial face carrying 3 rounded protrusions below superior crest, each with a few setae. Superior margin with slight longitudinal ridge that continues obliquely from plaque crest to near *linea impressa*. Tip of dactylus rounded in immature males and in females, acute in larger males. Plunger of dactylus large and continued distally as rounded crest; crest fitting neatly into narrow gap in distal margin of propodal "socket" (fig 86f). Merus 1.5 times as long as broad with superior margin distally projecting and acute; inferointernal margin bearing 3-5 small spines, distally rounded.

Small chela without sexual dimorphism, about 0.75 as long as large chela, 3 times as long as broad, fingers and palm equal. Dactylar articulation flanked by acute tooth medially. Inferior margin of palm with 5 slight notches bearing tufts of short stiff setae. Merus similar to that of large chela.

Carpal articles of second leg with ratio: 10:5:3:3:5; first article 3.6 times as long as broad distally and second article 1.7-2.0 times as long as broad.

Ischium of third leg unarmed. Merus 3.2 times as long as broad, distally armed with an acute tooth on inferodistal angle. Carpus 0.5 as long as merus; superodistal margin somewhat projecting, inferior distal angle an acute tooth. Propodus nearly as long as merus, slightly arched, bearing on its inferointernal margin about 9 slender spines and a pair distally. Dactylus 0.4 as long as propodus and biunguiculate. Secondary unguis inferior and 0.3 length of superior. Propododactylar articulation bearing small extra sclerite, a "heel" that is exposed when dactylus is so extended as to make an oblique or right angle to superior surface of propodus (fig. 86l).

Second pleopod of male with elongate *appendix masculina*, 1.5 times as long from base as adjacent lobe of endopodite and more than twice as long as *appendix interna*; *appendix interna* of second pleopod of female 0.2 length of endopod and originating at 0.6 length of ramus, not reaching to endopodal tip.

DISCUSSION: We have previously described an extra sclerite at the propododactylar articulation in *M. rostratipes* (1959:139); in the same paper we pointed out the form of the chelae in that species varies with age and sex.

BIOLOGICAL NOTES: This species occurs largely in dead coral, calcareous algae and under rocks inter- and sub-tidally. One of Coutière's specimens came from an abandoned teredo hole in a piece of wood. It has been dredged as deep as 11 fathoms. It is not a large species with our largest specimen being 18 mm.

AUSTRALIAN DISTRIBUTION: *M. paragracilis* has been collected on the west coast from Houtman Abrolhos to Dirk Hartog Island; in the north from Murray Island in the Torres Straits; and on the east coast from Diamond Islands in the Coral Sea south to Cape Moreton, Qld.

GENERAL DISTRIBUTION: This species extends from the Red Sea and Madagascar across the Indo-Pacific to Hawaii and the Societies. Chace (1966:627) found that specimens collected at St. Helena Is. in the Atlantic were indistinguishable from specimens from Hawaii. So the species must be circumtropical, although it is strange it

has not been found in other more extensive Atlantic collections.

Metalpheus rostratipes (Pocock)
Fig. 87

Alpheus rostratipes Pocock, 1890:522.

Metalpheus rostratipes Chace, 1972:78. (see also *Alpheus sp, Metalpheus,* n. gen.? Coutière, 1908a:213; 1921:419, pl. 62, fig. 15.)

Alpheus rostratipes Crosnier and Forest, 1965b:605; 1966:246, figs. 12-14.

Crangon hawaiiensis clippertoni Schmitt, 1939:11.

Alpheus clippertoni Chace, 1962:609. Banner and Banner, 1964:89.

Crangon nanus Banner, 1953:90, fig. 30. *(Nec Crangon nanus* Krøyer, 1842:231).

Alpheus huikau Banner, 1959:139, fig. 5.

SPECIMENS EXAMINED: 4 specimens from BAU 33; 2, BAU 47.

DIAGNOSIS: Rostrum acute, short, hardly reaching past orbital margins, without distinct carina, separated from orbital hoods by shallow rounded concavities. Orbital hoods projecting but rounded. Antennular peduncle stout, with second article a little broader than long. Visible part of first antennular article equal in length to second; third slightly longer. Stylocerite with acute tip reaching beyond first antennular article. Scaphocerite with squamous portion broad, reaching to near middle of third antennular article; lateral tooth prominent, reaching to end of antennular peduncle. Lateral tooth of basicerite strong, reaching to middle of second antennular article.

Third maxilliped with ratio of articles: 10:2.5:4.2; basal article 2.7 times as long as broad in midsection.

Large chela strongly compressed laterally, twice as long as broad. Superior margin with ill-defined ridge extending distally from *linea impressa* obliquely to crest for palmar adhesive plaque. Distal section of palm twisted slightly laterally. Lateral face of palm with 2 shallow grooves, superior arising near point of articulation of dactylus; inferior arising on propodal finger near socket for dactylar plunger. Neither reaching to middle of palm. Superior margin of dactylus rounded, not sharply carinate, tip rounded to acute and reaching beyond pollex. Plunger and socket similar to that of *M. paragracilis.* Merus almost as long as broad, bearing on its inferointernal margin 4 small spines; rounded distally. Superodistal margin not projected.

Small chela variable with maturity and sex. Small chela of male 2.7 times as long as broad, fingers and palm almost equal, dactylus slender with acute tip reaching beyond tip of pollex. Inferior margin of propodus opposite articulation of dactylus with strong concavity, and bearing proximally 4-5 spines. Chelae of females and immature males without elongation of dactylus and often without spines on inferior margin. Merus often heavier than that of mature males.

Second leg stout, with ratio: 10:5:4.3:2.9:7. Second to fourth articles as broad as, or broader than, long.

Ischium of third leg unarmed. Merus unarmed and flattened, 2.2 times as long as broad, medial face slightly concave. Carpus 0.5 as long as merus, slightly curved, superodistal angle projecting but rounded. Propodus slightly shorter than merus, curved and bearing on inferior margin about 5-6 spines with a pair distally. Dactylus 0.3 as long as

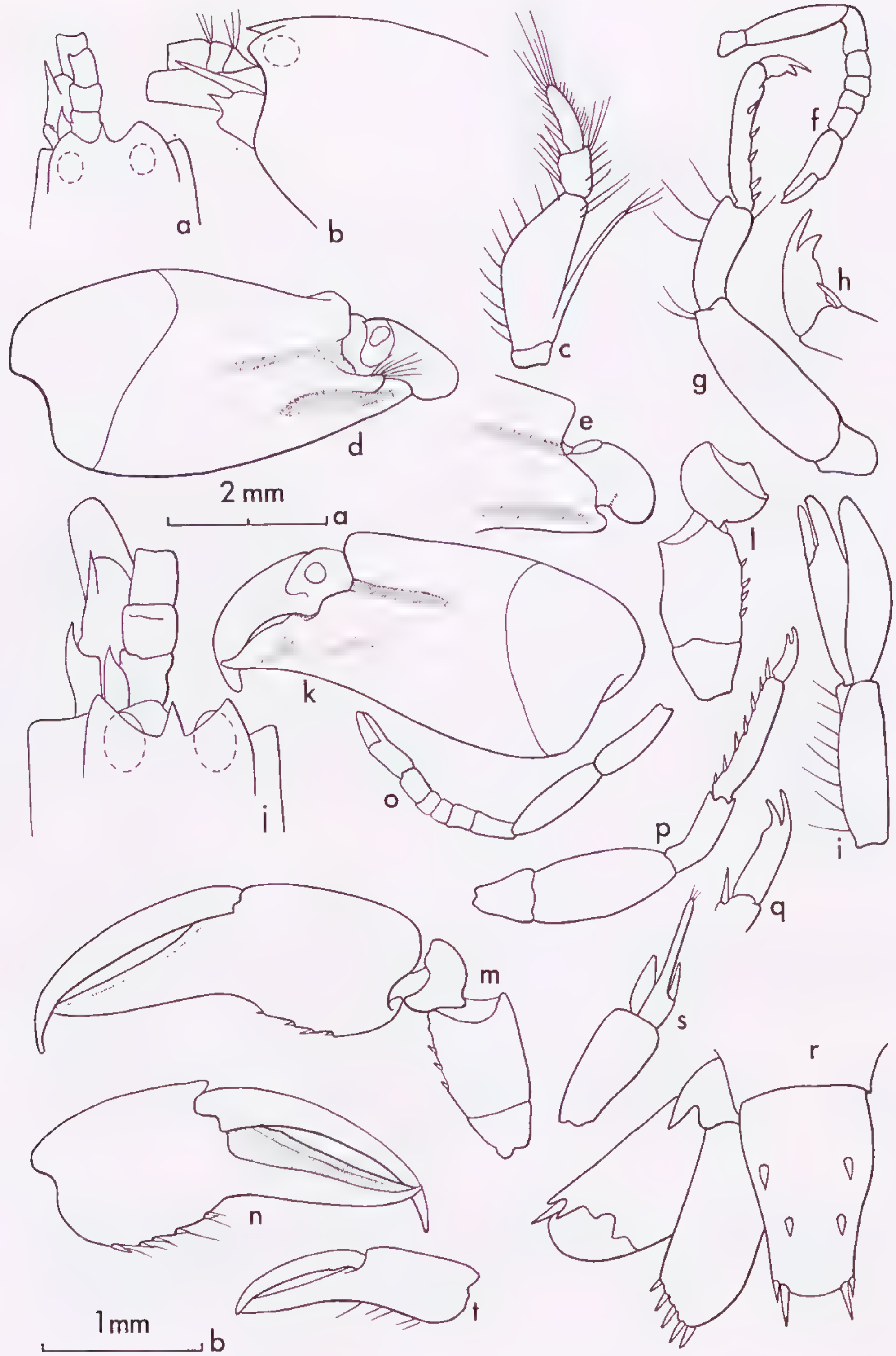

Fig. 87 *Metalpheus rostratipes* (Pocock)
15 mm female from BAU 47. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d, e.** large chela, lateral face and detail of dactylus; **f.** second leg; **g, h.** third leg and enlarged dactylus; **i.** second pleopod. 12 mm male from BAU 47. **j.** Anterior region, dorsal view; **k, l.** large chela, lateral face and merus, medial face; **m.** small cheliped, medial face; **n.** small chela, lateral face; **o.** second leg; **p, q.** third leg and dactylus; **r.** telson and uropods; **s.** second pleopod. 9 mm female from Hawaii. **t.** Small chela, lateral face. a, b, c, d, e, f, g, j, k, l, m, n, o, p, r, t scale a; h, i, q, s scale b.

propodus, biunguiculate, inferior unguis almost as long as superior. Inferior margin bearing swelling proximal to base of inferior unguis. Propododactylar articulation bearing extra sclerite as a "heel" when dactylus is extended to form right angle with a superior propodal surface.

Endopods of 2-4 pleopods of female with *appendix interna* arising in distal half, broadened and reaching to near end of endopod proper. *Appendix masculina* of second pleopod of male 2.5 times length of adjacent *appendix interna*.

Telson 2.5 times as long as posterior margin is broad. Inner spine of posterior pair 2 times as long as dorsal spines. Distolateral margin of inner uropod bearing about 5 strong spines.

DISCUSSION: This species has a long history of separate descriptions and names from various parts of the world which were finally synonymized by Crosnier and Forest (1966:*loc. cit)* as *Alpheus rostratipes*. They also present a complete description and illustrations. We have in the collection from Australia only 6 specimens. The specimens agree well with those descriptions presented heretofor. As Banner (1959) points out, the females and the smaller males (under the name *A. huikau*) have rounded tips to the dactyli of the large and small chelae, while in the larger males the dactyli are longer, more gradually curved with the tips more acute. This dimorphism was found in the two complete Australian specimens (see figs. 87d, k). In the same publication Banner described the extra "heel" sclerite on the walking legs.

We have sought the specimens that Coutière discusses from the Percy Sladen Trust Expedition as *Alpheus* sp? to see if we could confirm their identity and also to discover where the expedition collected it in the Indian Ocean. However, these, like some other specimens from the same expedition could not be found in any of the museums where Coutière deposited his material (Paris, Amsterdam, Leiden, London and Cambridge). We agree with Crosnier and Forest (1966:250) that on the basis of the published description and figures, there was no basis for the separation of Coutière's *Alpheus* sp? from *M. rostratipes* despite Coutière's doubts.

BIOLOGICAL NOTES: This species is small, not over 15 mm in length. It has been collected from the intertidal zone down to 15 m from under rocks, from dead coral and from calcareous algae.

AUSTRALIAN DISTRIBUTION: Two of the specimens were collected intertidally at Heron Island in the Capricorn Group, the others were collected off Port Douglas in 6-10 ft of water.

GENERAL DISTRIBUTION: This is a circumtropical species. In the Indo-Pacific we have yet unreported specimens from Madagascar and from there it ranges to the Hawaiian and Tuamotuan Archipelagoes. In the Eastern Pacific realm it is known from Clipperton Island. In the western tropical Atlantic, it has been reported from the Caribbean and Fernando de Noronha (the type locality), and in the eastern Atlantic from the Gulf of Guinea.

Family **Ogyrididae**

Ogyridae Hay and Shore, 1918:388

Ogyrididae Holthuis, 1955a:93.

DIAGNOSIS: Carapace without cardiac notch. Anterior margin with small rostrum, with 1 or more movable spines along midline posterior to rostrum. Pterygostomial angle produced, rounded. Abdominal pleura rounded; pleura of sixth abdominal segment not articulated. Telson with posterior margin markedly produced beyond posterolateral spines, tip rounded or slightly acute, sides sinuate. No transverse articulation on posterior section of outer uropods.

Eyestalks uncovered, elongate, cylindrical, pubescent and reaching at least to end of antennular peduncles; corneal surfaces reduced.

Antennular peduncles slender; flagella not bifurcate. Stylocerite with 2 strong acute teeth. Scaphocerite with squamous portion confluent with lateral tooth.

Mandible with incisor process reduced; palp of two articles. Following mouthparts similar to those of *Alpheus* (Coutière, 1899:333). Ultimate article of third maxilliped much shorter than penultimate.

First legs smaller than second, feeble, symmetrical with chela shorter than carpus. Second legs chelate, carpus having 4 or 5 articles.

Posterior thoracic sterna may bear a thelycum-like structure in both males and females. In some species the *appendix masculina* of second pleopods reduced or absent.

DISCUSSION: The familial relationship of the sole genus *Ogyrides,* for which the family was created, has been subject to discussion and several changes since Stimpson first described the genus (as *Ogyris)* without designation of family in 1861. Coutière in 1899 decided that it was close to the genus *Automate* and therefore placed it in the Alpheidae. Hay and Shore placed the genus in this separate family in 1918 as Ogyridae and suggested it lay between the families Alpheidae (then Crangonidae) and Hippolytidae. They were not aware that Stebbing in 1914 had found the name *Ogyris* occupied and had changed it to *Ogyrides,* thereby placing the extra syllable also in the family name. Armstrong (1949) rejected the family of Hay and Shore and placed the genus in the Hippolytidae, as had Ortmann in 1893. In his comprehensive review of the caridean and stenopodidean shrimp Holthius (1955a:93) maintained Hay and Shore's family, but combined it with Alpheidae, Hippolytidae and Processidae into the superfamily Alpheoida. Since that date there has been no further discussion of the family relationships. We accept Holthuis's determinations, but we have included the family in this work merely because it was included by Coutière and De Man in their important publications.

We agree with Hay and Shore that the presence of the thelycum-like structure, the small size of the first chelipeds, and the elongate and exposed eyestalks warrants the separation of this genus from the family Alpheidae and we accept Holthuis' erection of the superfamily Alpheoida.

The exact morphology of the thelycum-like structure on the specimens at hand is difficult to determine because of their small size and poor condition, but we do suggest that it may not be homologous nor analagous to the well-studied thelycum of the penaeids. In the penaeids the structure between the fourth and fifth legs is an outgrowth of the sternal plates of the female alone and is considered to be for the reception of the spermatophores. As others have remarked, in Ogyrides, both the males and females carry comparable structures. In the genus the main structure, a deeply notched — forwardly-directly plate lying in the midline, appears to be derived from the coxae of the fourth legs as well as the sternum (Pl. 1, and see Kemp, 1915:fig. 30d). In addition in the species *O.delli* (but not remarked upon for other species) the coxae of the last thoracic legs of the males carry two setiferous lobes which in the females unite to form a low,

continuous setiferous process reaching from leg to leg (fig. 88q). It is probable that these unique structures play some role in reproduction, but until copulation is observed it is difficult to imagine how they may be used. To speculate further, the hair-like structures that appear upon all coxae and other associated parts, but especially on the coxae of the fourth legs, as shown in Plate 1, are reminiscent of the sensilla shown in the SEM photograph of a calanoid copepod given by Fleminger (1973, fig. 2). Fleminger reported that the copepods he studied were almost blind, and suggested that these sensilla with the associated integumentary glands were part of the species-specific pheromonal system for detecting members of the opposite sex for reproduction.

Genus **Ogyrides** Stebbing

Ogyris Stimpson, 1861:36. (Junior synonym of: "*Ogyris* Westwood, 1851, in: Doubleday and Westwood, Gen. diurn. Lep.: pl. 75 (Lepidoptera)" see Holthuis, 1955a:93).

Ogyrides Stebbing, 1914:31.

TYPE SPECIES: *Ogyris orientalis* Stimpson, 1861:36.

This genus has the characteristics given for the family. Within the genus are 11 species, 5 of which have been reported for various parts of the Indo-Pacific, with two known from Australian waters. Where the habitat has been described for the various species, it has always been a muddy sandy substrate in waters of varying depth.

KEY TO THE SPECIES OF THE GENUS OGYRIDES IN AUSTRALIAN WATERS.

1. Carpus of second leg of 5 articles, but with first articulation faint and probably vestigial; with 4-8 movable spines on midline of anterior carapace ..*O. delli* (p. 289)

   Carpus of second leg of 4 articles; with 3-4 movable spines on midline of anterior carapace ....*O. mjobergi* (p. 294)

Ogyrides delli Yaldwyn
Fig. 88, 89

Ogyrides n. sp. Richardson and Yaldwyn, 1958:36, fig. 31.

Ogyrides delli Yaldwyn, 1971:89.

SPECIMENS EXAMINED: 1 specimen from AM P. 20709; 4, AM P. 21599; 1, AM P. 21872; 1, AM P. 21873. (All Australian specimens males; females found in paratypic series from New Zealand loaned by the National Museum of New Zealand through the courtesy of Dr J. C. Yaldwyn).

DESCRIPTION: Rostrum triangular, subacute at tip, as long as broad at base and as long as extracorneal teeth. Extraorbital teeth rounded, infracorneal teeth shorter than extracorneal, but acute. Pterygostomial angle projected but rounded. Posterior to rostrum carapace not carinate, but bearing in midline 4-7 heavy movable spines directed forward. Carapace covered with a light pubescence. Eyestalks reaching to end of antennular peduncles, thicker at base and tapering towards slightly expanded cornea. Cornea occupying only small proportion of stalk. First antennular article 1.4 times length of second when measured from base of rostrum; third article 0.7 as long as second, second article 2 times as long as broad. Stylocerite with 2 strong teeth, superior tooth reaching end of first antennular article and inferior tooth a little longer. Squamous

Fig. 88 *Ogyrides delli* Yaldwyn
22 mm male from AM P. 21599. **a, b.** Anterior region, dorsal and lateral view; **c.** third maxilliped; **d.** first leg; **e.** second leg; **f.** second leg, cleared; **g.** third leg; **h, i.** fourth leg and inferior view of dactylus; **j.** fifth leg; **k, l.** two views of second pleopod; **m.** telson and uropods. 28 mm ovigerous female paratype from New Zealand. **n.** Second pleopod. 18 mm paratype from New Zealand. **o.** Second leg, cleared; **p.** telson; **q.** "thelycum"-like structure. a, b, c, d, e, f, g, h, i, j, m, o, p, q scale a; k, l, n scale b.

portion of scaphocerite broad, lanceolate, lateral tooth of minimal development, often absent, reaching past middle of third antennular article. Carpocerite as long as antennules. Distoinferior margin of basicerite bearing 2 small acute teeth.

Third maxilliped much longer than antennules. Ratio of articles: 10:5:2. Inner faces of article carrying rows of setiferous bristles with those of last article the longest.

First chelipeds 0.4 as long as third maxilliped, symmetrical. Ischium 0.5 length of merus, bearing rounded protrusion on inferior margin. Merus 3.5 times as long as broad. Carpus 3 times as long as broad distally, with distal end twice as broad as proximal and bearing setiferous bristles on lower margins. Chela not as long or as broad as carpus, with fingers 1.6 times length of palm.

Carpal articles of second legs five, of variable length, with the approximate ratio of 10:3:4:3:5. (Note: the articulation between first and second carpal articles difficult to see — see DISCUSSION).

Third leg with ischium unarmed, nearly as long as merus, but slightly more slender. Merus 3.5 times as long as broad, bearing massive spine subterminally on inferior margin. Carpus 0.7 as long as merus, greatly broadened distally, and bearing many long forward-sweeping setiferous bristles on its surfaces. Propodus stout, 2 times as long as broad, with margins beset w'th strong setae, bases of which form a serrated edge. Dactylus spatulate, a little longer than propodus. Fourth leg of more normal form and slender. Ischium 0.8 as long as merus. Merus over 6 times as long as broad, inermous, but bearing long setiferous bristles on inferior and superior margin. Carpus 0.6 as long as merus. Propodus slightly longer than carpus and tapered distally. Inferior and superior margin of both carpus and propodus bearing long forward-sweeping setiferous bristles. Dactylus spatulate and curved, 0.5 as long as propodus. Fifth legs very slender, ischium 1.4 times as long as merus; merus 7 times as long as broad; carpus, propodus and dactylus of approximately equal length, each about half length of merus and each bearing long setiferous bristles; dactylus spatulate.

Thelycum-like structure of males a narrow, elongate process, lying between coxae of fourth legs (seventh thoracic segment) and ventral to sternal plates; anteriorly reaching to base of third legs; anterior margin with "V"-shaped cleft; lateral margins slightly concave; posterior margins apparently attached to coxae of legs and to sternum. Coxae of last thoracic legs bearing slight setiferous lobes pointing forward and attached at approximately the same point as in the "thelycum" of fourth legs. "Thelycum" of females similar to males, but with the setiferous lobes of the coxae of the fifth legs joining as a flap or lobe of thoracic sterna and becoming a low continuous and setiferous, flap-like process reaching from leg to leg.

Endopod of second pleopod carrying only *appendix interna* in both sexes; that of female shorter and attached slightly distal to middle; that of male longer and attached about one-quarter of length from base. Male *appendix interna* also with heavy setae on rounded lobe (probably vestige of *appendix masculina*) near articulation of *appendix*. Basipodite of male 2.8 times as long as broad while in female it is 4.0.

Total length of telson 2.5 times breadth measured at posterolateral spines; tip of telson extended and arcuate, part beyond posterolateral spines representing 0.3 of total telson length. Lateral margins bearing broad, low rounded projection just anterior to middle. Outer spines of posterolateral pairs very small; length of inner pair variable, at times half as long as median projection. Anterior pair of dorsal spines placed slightly anterior to middle, posterior pair well back. Outer uropod longer than telson, lanceolate in shape, tip rounded, without distal articulation.

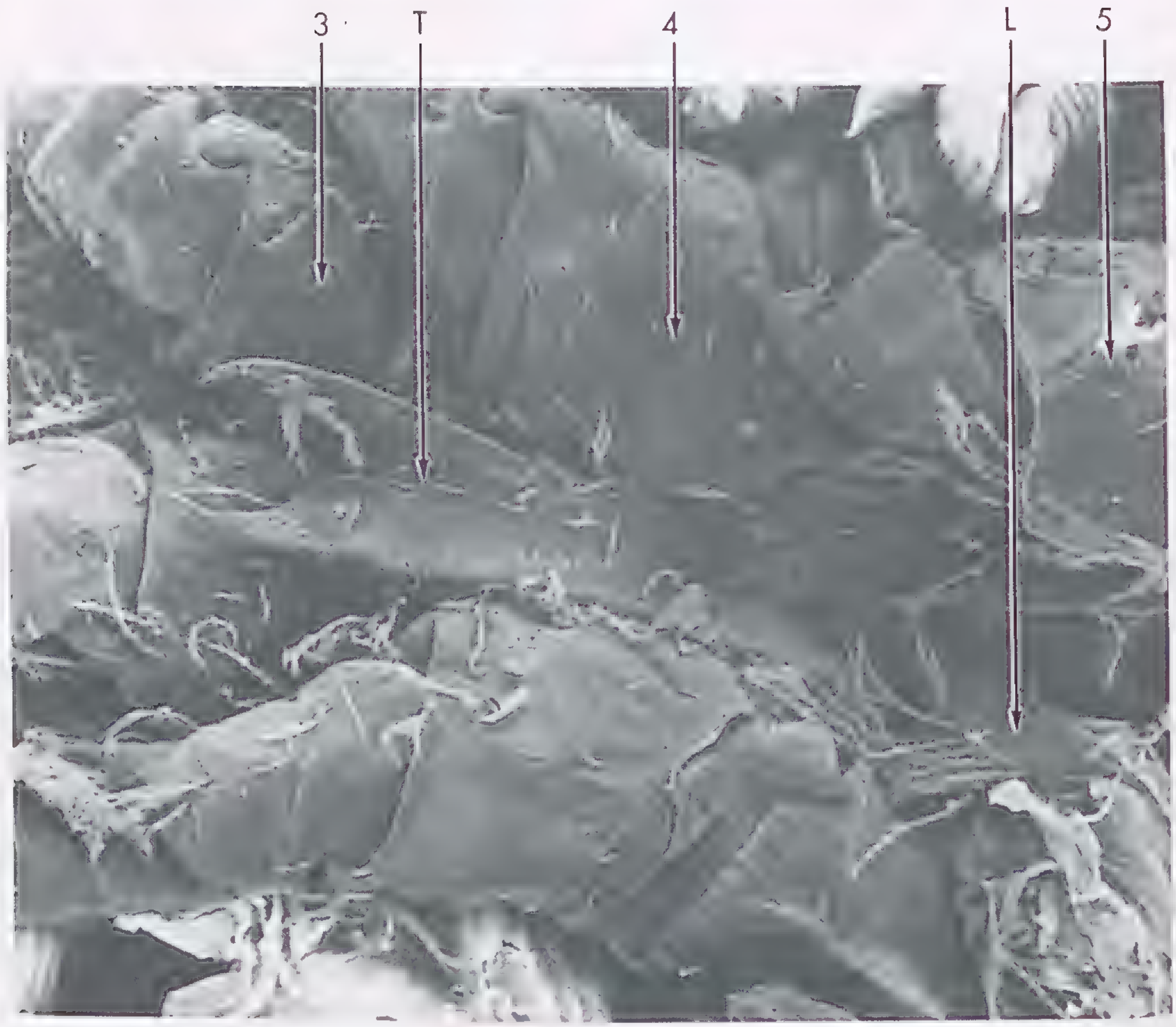

Fig. 89. *Ogyrides delli* Yaldwyn
20 mm male specimen from AM P. 21599. Scanning electron microscope photograph of ventral side, posterior thoracic segments. 3, 4, 5 bases of thoracic legs, as numbered; **T,** notched plate of thelycum-like structure, **L,** setiferous lobe. SEM photography made by Dr Arthur N. Popper, Department of Zoology, University of Hawaii, Honolulu, Hawaii.

DISCUSSION: An important characteristic within this genus is the number of carpal articles of the second legs. *O. orientalis* Stimpson may have 3 — see p. 294. The rest have been described with four articles except the following three species: *O. saldanhae* Barnard (described as: "Wrist of second legs with 4 jointlets, but the basal one often with marginal notch indicating incomplete division (five jointlets)" Barnard, 1950:726); *O. rarispina* Holthuis (described as "the carpus is divided into five jointlets . . . (in some the proximal articulation is less distinct than the distals)" Holthuis, 1951:133) and *O. delli*. *O. saldanhae* and *O. rarispina* come from the Atlantic; *O. orientalis* and *O. delli* from the Pacific. When we first examined the Australian specimens we did not detect more than 4 articles with at times a "bump" on the initial article and when we examined the paratypes from New Zealand we could find no more of an indication of the articulation than we did in the Australian. It was only after we cleared the exoskeleton of the appendage in sodium hypochlorite solution (household bleach), stained it lightly with Fast Green and mounted it in Euparal that the proximal articulation was clearly visible. However, the articulation appears to be degenerate and possibly non-functional as there does not seem to be any indentation nor other clear separation on the superior margin where the two subarticles join, and very little separation on the inferior margin. It is certainly not as heavy and well-formed as are the distal articulations. The New Zealand and Australian specimens show similar development (see figs. 88 f and o).

There is a slight difference in the number of dorsal spines on the carapace between the Australian and New Zealand forms. They were described by Yaldwyn as 6 to 8 in number, and in the 10 Australian specimens the number varied from 4 to 5. However, we counted the spines on 29 specimens from a single dredge haul from New Zealand and found 6 specimens with 5 spines, 13 specimens with 6 spines and 10 specimens with 7 spines. No apparent specific nor subspecific value should be placed upon this characteristic; this also reduced the value placed by Yaldwyn (1971:89) upon the use of this characteristic to separate the species from *O. rarispina*. The separation of the 3 species with the reported 5 carpal articles then rests upon the characteristics of the telson, a structure we have not studied in detail.

The Australian specimens were found to vary in their rostrums, which at times were somewhat shorter to somewhat longer than extracorneal teeth; in width of the scaphocerite, but which was always lanceolate; the length of the scaphocerite, which varied from reaching to the end of the second antennular article to reaching to the middle of the third; and in the length of the eyes, which varied from a little shorter to a little longer than the carpocerite.

We were able to compare the Australian specimens with 2 specimens of *O. orientalis* (Stimpson) collected from near the type locality of Kagoshima Bay, Japan and loaned by Dr Yasuhiko Miya of Nagasaki University, Japan. On these the carpus of the second legs was apparently of four articles as described by Stimpson (see p.294) and later workers (we did not remove the legs and clear them), and there was one other difference between them and the specimens from Australia, possibly of importance. The Japanese male specimen carried an *appendix masculina,* similar to the one discussed and figured by Fujino and Miyake (1970:255, fig. 6B) while in all 10 male specimens from Australia the process was lacking and its site was marked by only a slight lobe that carried strong and slightly curved setae (fig. 88 k,l). Otherwise the Australian and Japanese specimens were very similar.

BIOLOGICAL NOTES: This species apparently is a burrowing form in sand bottoms and has been collected both from bare sand and sea grass beds in shallow water; one specimen was dredged near Sydney at 30 fathoms. Yaldwyn reported (*loc. cit.*) that in New Zealand specimens the colour in life was transparent with prominent transverse

bands of red posteriorly on each abdominal segment.

AUSTRALIAN DISTRIBUTION: Specimens have been collected in Moreton Bay, Qld, and from near Sydney, N.S.W.

GENERAL DISTRIBUTION: The species is known only from Australia as indicated, and from the North Island, New Zealand.

Ogyrides mjobergi (Balss)
Fig. 90

Ogyris Mjöbergi Balss, 1921:7, figs. 1, 2.

Ogyrides mjöbergi Holthuis and Gottlieb, 1958:48, fig. 10. Ledoyer. 1968:75, pl. 11, fig. 1A-11A; 1970:128.

DIAGNOSIS: "The rostrum is triangular and somewhat shorter than the extraorbital teeth; on the carapace behind it lies 3 teeth (spines) in a straight line; there is no crest. The orbits (the eye sockets) are rounded and there is barely an indication of an antennal (infracorneal) tooth. The pterygostomial angle is obtuse. The abdominal pleura have rounded margins. The shape of the telson is similar to those of *Ogyris Sibogae*: it carries on the middle of the lateral margins a prominence (an obtuse but definite angular protuberance), on the end of the sides a spine and the posterior margin is rounded oval.

"The outer uropods are pointed and are longer than the telson, the inner somewhat shorter than the outer.

"The eyestalks are longer than the antennular peduncle and about the same length as the antennal peduncle; the stylocerite has two points and the outer tooth is somewhat longer than the inner. The antennal squame reaches about to the end of the second antennular article; it is blunt at the end and carries on the outer.margin a clear tooth.

"The terminal article of the third maxillipeds is lacking.

"The first chelae are symmetrical and similar to those of *Ogyris Sibogae*.

"Also the second chelae are built similarly to those of *Ogyris Sibogae*; the carpus is of four articles. The following thoracic legs are lacking.

"Measurement: Length of the carapace 5 mm, of the abdomen 14 mm." (Translated from the German by the authors.)

DISCUSSION: Balss separated this species from *O. sibogae* De Man (1911:135, fig. 1), which he considered to be very close, on the basis of three characteristics: the rostrum was shorter than the extra-orbital teeth instead of longer; the antennal scale was truncate instead of pointed; and the carapace carried three movable spines instead of four. He also suggested that the smaller specimen that De Man discusses under the same name (from Siboga station 313, *loc. cit.*) may be identical with *O. mjobergi;* Holthuis and Gottlieb (*loc. cit.*) agree. Ledoyer (*loc. cit.*) remarked upon the variation he has found in specimens from Madagascar that he identified as *O. mjobergi* and suggested that the species may be found to be a synonym of *O. sibogae* but continued the separation based on the shape of the tip of the antennal squame.

In separation action, first Yokoya (1927:171, pl. 7, fig. 1-16) pointed out that *O. sibogae* did not differ materially from a specimen from Japan probably identical with *O. orientalis* (Stimpson) (1861:105) if one interpreted Stimpson's description of the carpus of the second legs as *"triarticulatus"* to mean with three articulations and four articles*.

*Dr. Fenner A. Chace, Jr. has pointed out to us that Stimpson used the same word *"triarticulatus"* to describe the carpus of his genus *Virbius* on the preceding page, and *Virbius* carries 2 secondary articulations and 3 articles (personal communication).

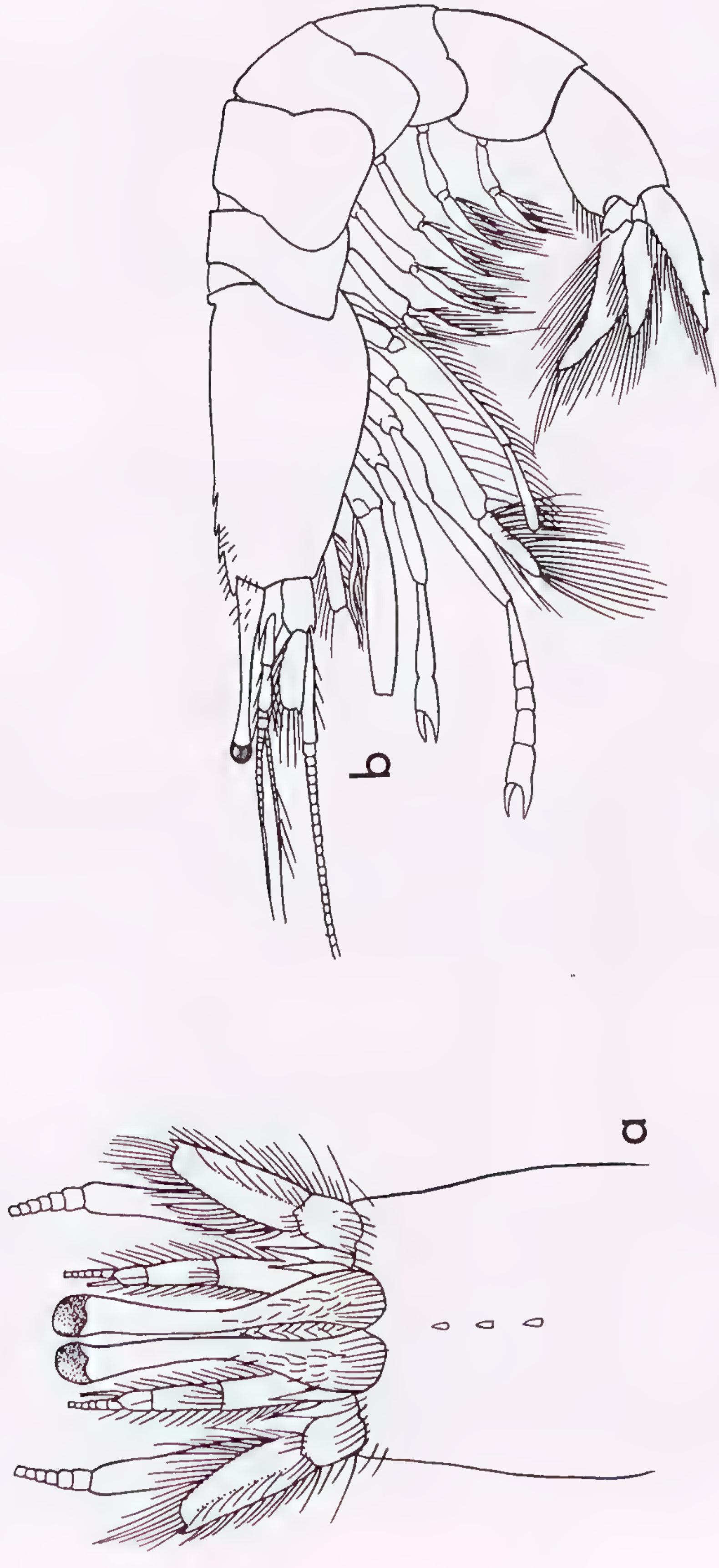

Fig. 90 *Ogyrides mjobergi* (Balss)
a. Anterior region dorsal view; **b.** whole animal, lateral view. (Figs. after Balss).

Yokoya stopped short of declaring *O. sibogae* to be a synonym. However, Fujino and Miyake (1970:255) with 2 specimens from the East China Sea did list *O. sibogae* as a junior synonym of *O. orientalis*. Therefore, if *O. mjobergi* is indeed a synonym of *O. sibogae*, the proper name for it would be *O. orientalis*.

We do not enter the discussion of synonymy at this time as we have no specimens we can identify as *O. mjobergi*. We would like to point out, however, that if the previous workers overlooked the first and vestigial articulation of the carpus of the second leg, it is possible that *O. delli*, as discussed above, its also a synonym of *O. orientalis*.

BIOLOGICAL NOTES: Ledoyer records the species being dredged from fine to muddy sand and depths from 6.5 to 37 m., but reports the workers on Madagascar did not collect it from the "sables grossiers" nor from beds of sea grasses.

AUSTRALIAN DISTRIBUTION: Balss' specimen came from 45 miles WSW from Cape Jaubert at a depth of 54ft.

GENERAL DISTRIBUTION: Mediterranean coast of Israel (Holthuis and Gottlieb *(loc. cit.)*. suggest it reached the Mediterranean Sea via the Suez Canal); Madagascar. (If the species is found to be a synonym of *O. orientalis*, the known distribution will be greatly extended).

Appendix I

TWO NEW SPECIES, NOTES AND ADDITIONAL RECORDS OF GENERA COVERED IN PARTS I AND II

Since the publication of Parts I and II of this study we have received many additional specimens for study from Australia. These collections contained two species that we recognize as new, two species previously unknown from Australian waters, together with many additional records of previously reported species, some of which are extensions of the ranges given in Parts I and II. Through examination of the type specimens we are able to settle the affinities of *S. haddoni*, questioned in Part II. All are reported in this appendix. References under *Additional Records* are to the earlier parts published.

NEW SPECIES

Synalpheus tijou sp. nov.

Fig. 91

HOLOTYPE: 14 mm female from Tijou Reef, Lizard Island, Great Barrier Reef. Living commensally with a crinoid. Collected by R. A. Birtles and L. P. Zaan, 11/11/73. (JC 42). (AM P.30809).

DIAGNOSIS: Dorsal surface of carapace entirely smooth without ridges or grooves. Anterior carapace greatly projecting, one third lying anterior to eyes; acute tip of rostrum reaching to near end of antennular peduncles. Orbital teeth suppressed, being low obtuse angles confluent with anterior margins of carapace and concave sides of rostrum. Pterygostomial angle rounded. Orbitorostral process lacking. First antennular article when viewed through the carapace 3 times as long as broad, 3 times as long as second,

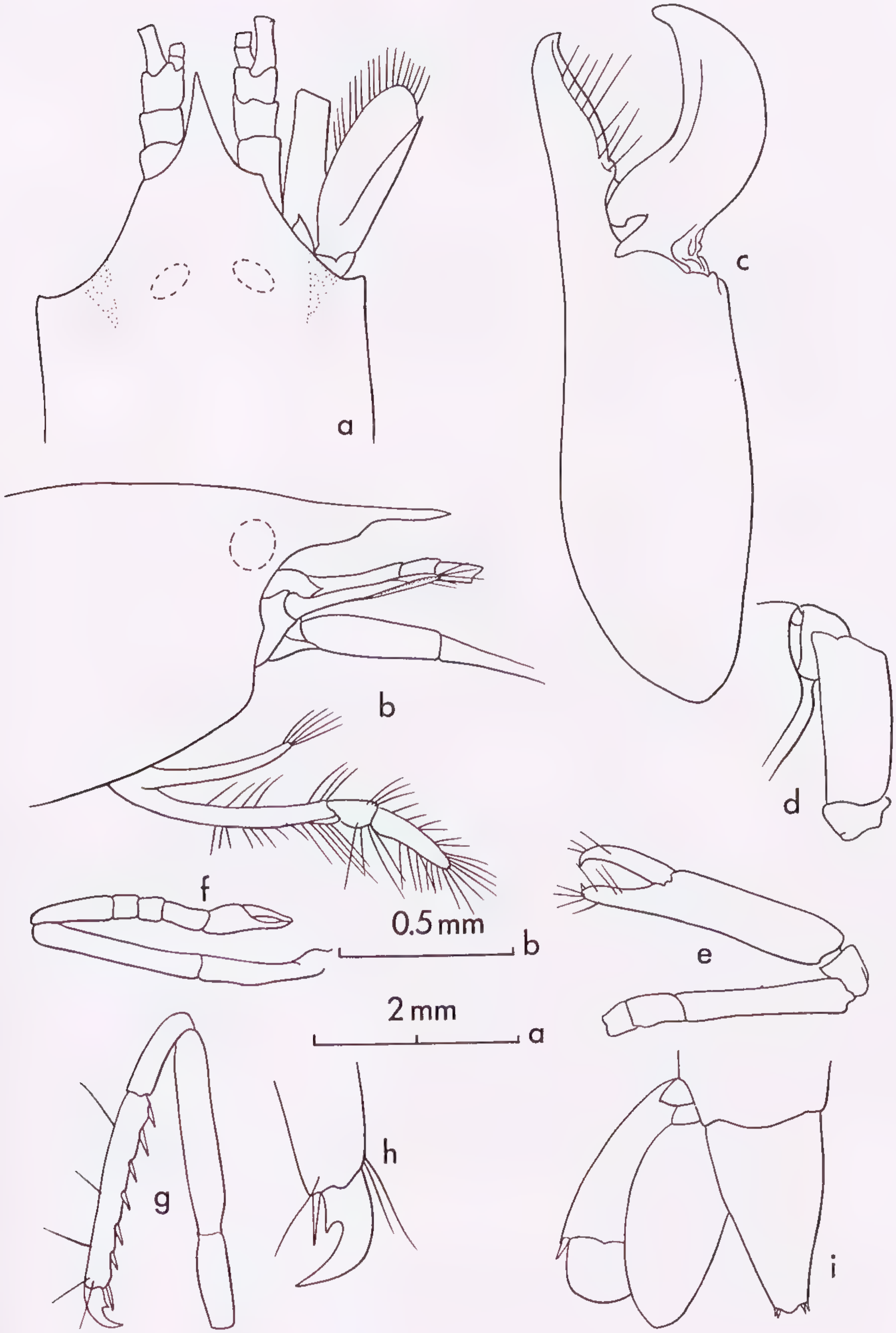

Fig. 91 *Synalpheus tijou* sp. nov.
Holotype (female). **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela and merus, lateral face; **e.** small cheliped, medial face; **f.** second leg; **g, h.** third leg and dactylus, enlarged; **i.** telson and uropods. a, b, c, d, e, f, g, i scale a; h, scale b.

second as broad as long and equal in length to third. Stylocerite minimal in size, reaching only 0.5 length of first antennular article. Statoliths plainly visible beneath the stylocerite. Squamous portion of scaphocerite broad, reaching near end of antennular peduncle, lateral tooth acute but markedly shorter than squame. Carpocerite 5 times as long as broad when viewed laterally, not reaching end of antennular peduncles. Basicerite without teeth.

Ratio of articles of third maxilliped: 10:2.4:5.1. Third article with a few heavy setae distally.

Large chela 3.2 times as long as broad, surface wrinkled from dessication, but normal chela is undoubtedly without grooves and may be thicker. No tooth on palm flanking dactylar articulation. Fingers 0.3 as long as entire chela. Plunger well developed. Merus 2 times as long as broad and without inferior and distal teeth. Small chela 5 times as long as broad, palm 2 times as long as fingers. Dactylus not broadened, tips of fingers acute, somewhat hooked and crossing when closed. Merus unarmed, slender, 6 times as long as broad in middle.

Second legs with only 4 carpal articles. Ratio of carpal articles: 10:3:3:5.

Ischium of third legs inermous, almost half as long as merus. Merus also inermous, 5 times as long as broad. Carpus 0.48 as long as merus, distal angles rounded and not projecting. Propodus as long as merus, bearing on its inferior margin 6 strong spines and a pair distally. Dactylus biunguiculate, 0.14 as long as propodus, tip curved at right angles to axis of propodus; inferior unguis arising in basal third of dactylus. Superior unguis 4.5 times as wide at the base as the inferior unguis and 4 times as long.

Telson 4.6 times as long as broad posteriorly and almost 4 times as broad anteriorly as posteriorly; posterior margin convex. No spines visible on superior surface; posterolateral spines small. Outer uropod with a distinct articulation.

DISCUSSION: The lack of oribitorostral process, the anterior region of the carapace advanced so far distal to the eyes, the markedly curved superior unguis of the dactylus of the thoracic legs and its association with a crinoid places this species firmly within the Comatularum Group of the genus *Synalpheus*. From all species within the group it differs by the extreme length of its rostrum and the great reduction of the orbital teeth; by the slender and elongate palm of the small chela; by the presence of 4 articles in the carpus of the second legs (if this is an adult condition); by the form of the dactylus of the third legs; and by the shape of the telson with its extreme taper and narrow tip. It may be separated from other species by other specific characteristics, as by the lack of a tooth on the base of the propodal finger of the large chela as found in *S. odontophorus* de Man, or the lack of a hooked dactylus of the small chela as in *S. comatularum* (Haswell), but the major differences listed above are more than sufficient. It appears to us that the species may be related most closely in the group to *S. stimpsonii* (de Man) but that species always has strong and distinct orbital teeth.

This specimen was evidently ready to moult or had recently moulted for the integument was soft and transparent, permitting one to see through it in places. Visible were slightly more pronounced orbital teeth and possibly one pair of dorsal spines on the telson. The soft exoskeleton had also caused the palms of both chelae to wrinkle, so that they may be more plump in a fully hardened specimen. The presence of four articles in the carpus of the second legs may be an indication of immaturity in the specimen (see discussion in B&B, 1975:298), but in no other members of the genus does one find immature traits in a 14 mm long specimen.

This species may be inserted into the key to *Synalpheus* by deleting the name *S. stimpsonii* from dichotomy 5 on p.279 (1975) and inserting the following:

5A (5) Rostrum not reaching near end of second antennular article; orbital teeth prominent and acute; carpus of second legs of 5 articles... *S. stimpsonii II:* 292

— Rostrum reaching near end of third antennular article; orbital teeth reduced to low obtuse angles; carpus of second legs of 4 articles ..*S. tijou*

This species may also be inserted in the key to the alpheids known to inhabit crinoids (1975:389) by converting the dichotomy under 6 to a trichotomy with the addtiion of:

— Rostral carina absent; tip reaching to near end of third article ....*S. tijou*

The name is derived from the type locality.

The holotype will be placed in the Australian Museum, Sydney N.S.W.

Synalpheus paralaticeps sp. nov.

Fig. 92

HOLOTYPE: 10 mm female from Rudder Reef, off Port Douglas, Qld. From outer reef flat, 200 yards from reef edge. Reef subject to heavy surf with S. E. winds. (BAU 30) (AM P.30810).

ALLOTYPE: 9 mm male from same collection. (AM P.30811).

DIAGNOSIS: Rostrum slender, 1.8 times as long as broad, reaching to last quarter of visible part of first antennular article, tip rounded. Orbital teeth as long as broad at base and almost as long as rostrum. Tip of rostrum and orbital teeth bearing a few short stiff setae. Rostral base with orbitorostral process. Second antennular article slightly longer than wide, 0.8 as long as visible part of first, and 1.5 times longer than third. Stylocerite reaching near middle of second antennular article. Scaphocerite with very narrow squame reaching to end of second antennular article, lateral tooth reaching nearly length of third article past that article. Carpocerite 5.6 times as long as broad, viewed laterally, and reaching well past end of lateral tooth of scaphocerite. Inferior tooth of basicerite reaching near end of second antennular article and superior tooth as long as orbital teeth.

Ratio of the articles of third maxilliped 10:1:6. Distal tip beset with a circlet of short spines.

Large chela cylindrical, 2.6 times as long as broad, with fingers occupying distal 0.3. Tip of dactylus abruptly rounded. Palm bearing one obtuse tubercle above dactylar articulation. Merus twice as long as broad, bearing a small acute tooth on superodistal margin. Small chela 2.8 times as long as broad with fingers 0.4 as long as palm. Dactylus bears 2 rounded curved teeth distally; pollex terminating in a single acute tooth flanked by two abrupt shoulders lying at right angles to axis of tooth. Merus 2.8 times as long as wide, unarmed. Carpus cup-shaped, 0.3 as long as chela.

Carpal articles of second legs with a ratio: 10:2:2:2:5; middle articles broader than long.

Ischium of third leg over half length of merus, unarmed. Merus 3 times as long as broad and bearing two small spines on inferior margin in distal third with a few hairs proximally. Carpus 0.4 as long as merus with superodistal margin bearing obtuse projection and inferodistal margin a small spine. Propodus 0.7 as long as merus, inferior margin with 6 pairs of spines interspersed with a few hairs. Dactylus biunguiculate, inferior unguis a little less than half as long as superior; apex of notch subacute.

Telson 3 times as long as tip is broad, 2.2 times as wide anteriorly as at tip. Anterior

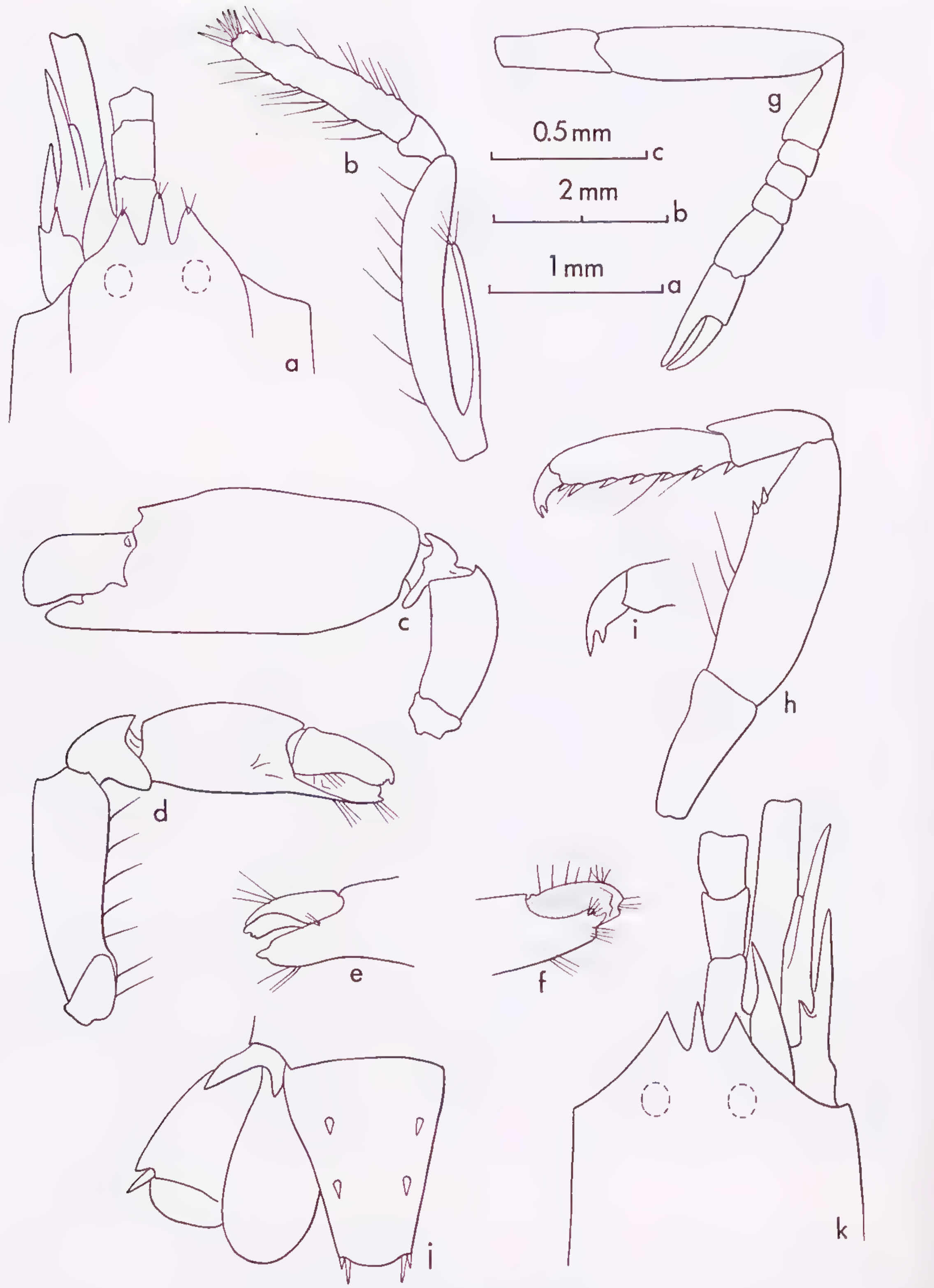

Fig. 92 *Synalpheus paralaticeps* sp. nov.
Holotype (female). **a.** Anterior region, dorsal view; **b.** third maxilliped; **c.** large cheliped, medial face; **d.** small cheliped, lateral face; **e, f.** distal region of small chela, medial and inferior face; **g.** second leg; **h, i.** third leg and enlarged dactylus; **j.** telson and uropods. Alloytype (male). **k.** Anterior region, dorsal view. a, b, g, h, j, k scale a; c, d, e, f scale b; i, scale c.

pair of dorsal spines placed well anterior to middle. Outer uropod with an articulation.

DISCUSSION: This species is similar to a compact group of three Australian members of the genus, *S. quadriarticulatus* B&B, *S. pescadorensis* Coutière, and *S. sciro* B&B (1975:297, 301, 304). The four species have similar development of the orbital teeth and rostrum, a reduced squame and long teeth on the basicerite of the antennae, a broadened and denticulate dactylus of the small chela, and a heavy carpus of the second legs with the middle articles broader than long; of these, the fingers of the small chela are the most outstanding characteristic. However, none of the three previously recorded species have the orbitorostral process and the articulation of the tip of the outer uropod. In addition, *S. paralaticeps* may be separated by other specific characteristics, such as the presence of spines on the merus of the third legs, the five articles of the carpus of the second legs as opposed to four in *S. quadriarticulatus,* the lack of a strong tooth flanking the dactylar articulation which is found in *S. pescadorensis* the longer teeth on the basicerite and the more slender merus of the third legs as found in *S. sciro*.

This species is close to the form from the southern Philippines we have interpreted to be *S. laticeps* which Coutière described from the Maldives (we have been unable to find the two type specimens of Coutière in the museums at Paris or Cambridge, and we will describe and figure our Philippine specimens in a later paper). These *S. laticeps* also have the orbitorostral process. The two species can be distinguished by the length of the first carpal article of the second legs — only twice its width in *S. paralaticeps* and about 3.5 times its width in *S. laticeps* — and in the third leg in which the merus is broader and carries 2 spines and the propodus carries fewer and heavier spines in the Australian species.

S. paralaticeps may be inserted in our key to the genus (B&B; 1975:280) by the modification of the dichotomy under *10* to read:

10. (9) Merus of third legs bearing two to many spines; dactylus of small chela with 2 or more teeth at tip, pollex with either several teeth or a single tooth flanked with abrupt shoulders 10A

— Merus of third legs unarmed; pollex of small chela tapering to single acute tip.. 11

10A. (10) Small cheliped short and heavy, with merus less than twice as long as broad and palm curved, 1.3 times as long as broad .... *S. harpagatrus* (II:311).

— Small cheliped of more usual proportions with merus 2.8 times as long as broad, palm 1.8 times as long as broad, and straight not curved .... *S. paralaticeps*

The specific name refers to the possible close relationship of this species to *S. laticeps* (see footnote p. 72).

The specimen will be deposited in the Australian Museum, Sydney, N.S.W.

NEW RECORDS

Athanas polynesia Banner & Banner
Fig. 93

Athanas polynesia Banner and Banner, 1966a:152, fig. 4.

SPECIMENS EXAMINED: 1 specimen from AM P. 25161; 3, 75-LIZ I (AM P. 28140); 2, 75-LIZ T (AM P. 28141); 2, 75-LIZ V (AM P. 28142).

DIAGNOSIS: Rostrum usually reaching to near end of second antennular article, usually acute at tip with slight carina, outer margins at times slightly flattened. Ventral side of rostrum with slight notch near tip bearing a stiff seta. Supracorneal teeth prominent, a little less than half as long as rostrum, rounded at tip; extracorneal teeth slender, reaching end of first antennular article. Rostrum and supracorneal teeth curving upwards. Antennules stout, visible part of first antennular article 2 times as long as second; second broader than long; third article 1.13 times longer than second article. Stylocerite reaching near end of second antennular article. Outer flagellum of 5 articles. Squamous portion of scaphocerite broad, reaching to end of antennular peduncle; lateral tooth a little longer. Carpocerite reaching end of antennular peduncle. Basicerite with small rounded lateral tooth.

Labrum enlarged, hemispherical. Mandible with *pars incisiva* expanded, fitting over labrum, with finely serrate cutting edge; palp large; *pars molaris* reduced. Maxillule with expanded middle lobe. Third maxilliped with ratio of article 10:3:5; superodistal margin of second article and superior side and tip of third article with groups of long setae; tip of third article narrow; medial face of second article with one, third article with six, rows of stiff bristles.

Chelipeds sexually dimorphic, but with propodal finger carried in superior position in both sexes. In males, chelipeds of similar general form but differing in size, both very flattened and evidently folding back on themselves so as to produce a broad flattened anterior surface. Large chela about twice as long as broad, very flattened and becoming lamellar towards margins, outer surface convex, inner surface concave except where muscles are placed; distal margins of palm and proximal portion of propodal finger serrate and carrying long setae. Finger 0.3 length of chela, propodal finger heavy at base, about 3 times as wide as adjacent dactylus; oppositional surfaces of both fingers carrying a low irregluar dentition, teeth not meshing; tips hooked and crossing. Ischium and merus broadened and flattened. Ischium heavy, 0.7 as long as merus, distally expanded and bearing spines and setae. Merus less than 0.5 length of palm, over twice as broad distally as proximally, 1.5 times as long as broad distally, unarmed. Carpus on inner face 1.3 times length of merus, proximally very thin rapidly expanding in proximal third and at end of expansion medial face marked by strong rounded tooth; distal portion with nearly parallel sides; superior margin convex, inferior margin concave, with medial margin of concavity lamellar. Small chela essentially like large chela, but only about 0.5 as long in each of its articles. Only one cheliped of female is known. It is conventional in shape, not flattened. Ischium 0.6 as long as merus, unarmed; merus twice as long as broad, unarmed; carpus distally expanded, 2.5 times as broad distally as proximally and 1.3 times as long as broad distally. Chela cylindrical in section, 2.8 times as long as broad, with fingers occupying distal third.

In the few specimens with second legs intact the ratios of the carpal articles varied: 10:(5-9):(4-5):(9-12).

Ischium of third leg without spine. Merus inermous, 4 times as long as broad. Carpus 0.5 as long as merus, not projected distally, but inferodistal margin bearing short spine. Propodus a little shorter than merus, bearing 5 spines on inferior margin with a pair distally. Dactylus simple 0.4 as long as propodus. Fourth leg more slender. Merus of fifth leg 2 times as long as broad, and 1.2 times longer than ischium, without spines or projections; propodus 2 times longer than merus, slightly arched and bearing only 3 spines near distal portion; dactylus as long as carpus.

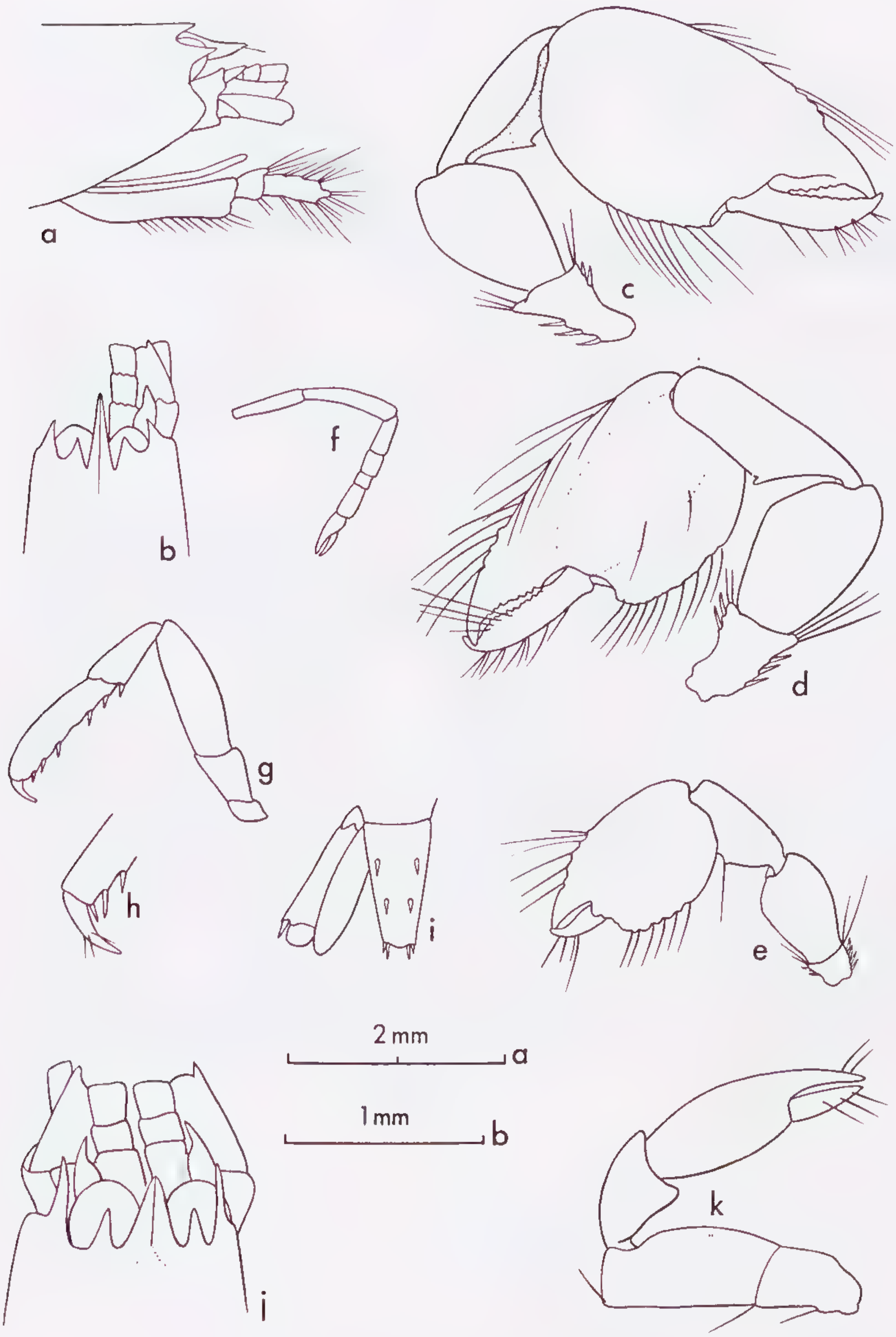

Fig. 93 *Athanas polynesia* B&B
8 mm male from AM P. 25161. **a, b.** Anterior region, lateral and dorsal view; **c, d.** large cheliped, lateral and medial face; **e.** small cheliped, lateral face; **f.** second leg; **g, h.** third leg and enlarged dactylus; **i.** telson and uropod. 8 mm female from 75-LIZ-V. **j.** Anterior region, dorsal view; **k.** cheliped, lateral face. a, b, c, d, e, f, g, i scale a; h, j, k scale b.

Telson 3.7 times as long as posterior margin is broad. Posterior margin arcuate, anterior pair of dorsal spines placed anterior to middle. Uropods elongate with outer uropod distally bearing articulation. Sympodite with two teeth, outer longer and broader than inner.

DISCUSSION: Unfortunately, most of these specimens are fragmentary. The seven specimens with the "LIZ" collection records are especially bad, with only 4 walking legs and one cheliped remaining attached; the male specimen from AM P. 25161, also from Lizard Island, is however complete. Extra appendages in the "LIZ" bottles agreed with the appendages that were attached.

There was only one female cheliped in the entire collection and females of this species have not been previously described. We suggest that the females probably have symmetrical chelae as has been reported in related species.

The rostrum in one specimen is short and somewhat distorted (fig. 92j); we suggest that it may be a malformation from heredity or accident, as we reported in a specimen of *A. borradailei* (Coutière) from Samoa (1966a:152). Otherwise in the intact parts only minor variation was noted, such as the range in the relative lengths of the carpal articles reported above. The specimens agree well with the specimens we described from Samoa; the similarities in the male chelae are especially striking.

There is a group of four nominal species that lie intermediate between the old genera of *Athanas* and *Arete;* they are *A. borradailei* (Coutière), *A. ghardaqensis* (Ramadan), *A. verrucosus* B&B, and this species. All carry the chela in an inverted position, with the dactylus in inferior orientation; in all males the palm is greatly widened and compressed, with associated modification of the merus and carpus to permit flexion; in all the bases of the antennules and antennae are heavy and in all of these species the mouthparts are greatly protrudant (the mouthparts for *A. ghardaqensis* have not been described, but we have specimens of it as yet unreported in our collections from Madagascar and the Red Sea). The only species that can be firmly separted from the others is *A. verrucosus,* for it has 5 carpal articles in the second leg rather than four. The other species, described on the basis of one or few specimens, often partially fragmentary, are separated by more subtle and variable characteristics and should be reviewed when a larger series of intact specimens are available (as we pointed out in 1960:149 and in 1966a:152). This compact group of species also should be considered in their generic relationship. In 1960 we considered them as intermediate between the previously separated genera of *Athanas* and *Arete,* so we combined the two genera. On the other hand, it may be more useful to consider them to be a separate genus, yet to be designated, which would permit the two previous genera to stand. With the present collections, however, nothing further can be done.

This species may be inserted into our key to the genus *Athanas* (B&B, 1973:303) by substituting the following for dichotomy 10:

"10 (1) With supracorneal spines; dactylus of third to fifth legs simple .... *A. polynesia*

— Without supracorneal spines; dactylus of third to fifth legs biunguiculate .... 11"

and renumbering the present dichotomy from *10* to *11.*

BIOLOGICAL NOTES: All of these specimens were reported as coming from areas largely covered with encrusting coralline algae in water from 6-20 ft deep.

AUSTRALIAN DISTRIBUTION: These Lizard Island specimens are the only ones

known from Australia.

GENERAL DISTRIBUTION: Samoa.

Salmoneus sibogae (De Man)*
Fig. 94

Jousseaumea sibogae De Man, 1910b:303; 1911:158, fig. 9.

SPECIMENS EXAMINED: 1, 14 mm male and 1, 10 mm ovigerous female from North Reef, Heron Island, Capricorn Group. Coll. A. J. Bruce, 4/1/77.

DIAGNOSIS: Surface of carapace finely granulate, bearing a slight pubescence of short stiff setae. Rostrum triangular, with somewhat concave margins, 1.3 times as long as broad at base, tip reaching to middle of third antennular article; carina slight extending prosteriorly from tip to level of middle of eyes. Extracorneal teeth triangular, about one-fifth as long as rostrum, with inner margins parallel to medial plane of body. Margin between extracorneal teeth and rostrum narrow but rounded. Antennular peduncle stout, with second antennular article slightly broader than long; antennular articles nearly equal in length. Stylocerite with acute tip reaching slightly beyond end of second antennular article. Scaphocerite with squamous portion broad, reaching just past antennular peduncle; outer margin straight; lateral tooth as long as squamous portion. Carpocerite stout, reaching just past end of second antennular article. Lateral tooth of basicerite broad and acute, reaching to level of tips of extracorneal teeth. Pterygostomial angle produced but rounded.

Large chela 3.0 times as long as broad, with fingers occupying distal 0.4, rotated about 90° with fingers opening laterally. Palm somewhat quadrangular but rounded in section without excavations, with heavy proximal shoulder and notch at carpal articulation, distally constricting opposite dactylar articulation. Fingers compressed, bearing 11 teeth that mesh exactly when closed; tips hooked and crossing. Carpus bearing 2 strong teeth on lower (medial) side, otherwise projecting in a cyathiform manner. Merus 8.3 times as long as broad in inferior view, unarmed; inferior face broadened, flattened to excavate, and curved to accommodate palm when carpal articles are flexed. Ischium about 0.4 length of merus (in female specimen; that of male broken).

Small cheliped of minimal size, when all articles are extended it is about 0.9 length of large chela proper, not showing sexual dimorphism. Ischium unarmed, 0.6 as long as merus. Merus 6 times as long as broad; carpus 0.8 as long as merus, almost 3 times as broad distally as proximally. Chela 0.7 as long as merus, with fingers a little shorter than palm.

Second leg with ratio of carpal articles: 10:5:3:2:5.

Ischium of third leg with 2 spines, merus 5.8 times as long as broad. Carpus 0.8 as long as merus, not projected distally; propodus 0.7 as long as merus bearing on its inferior margin 5 spines and a pair distally. Superior margin bearing a slender spine distally. Dactylus simple, 0.3 as long as propodus, bearing on its dorsal surface near the tip a small notch from which protrudes 2 fine hairs.

Telson 4 times as long as posterior margin is broad; posterior notch narrow, V-shaped, with depth equal to 0.5 breadth of tip. With usual posterolateral pairs of spines and long plumose setae arising in middle. Inner part of spines as long as outer (in female, spines on male telson missing). Anterior pair of dorsal spines set posterior to middle.

DISCUSSION: It is the 14 mm male that is the basis of this description unless

*This name will be reduced to a synonym of *S. serratidigitus* (Coutière, 1896b) in a forthcoming paper on the alpheids of the Red Sea and Gulf of Aden.

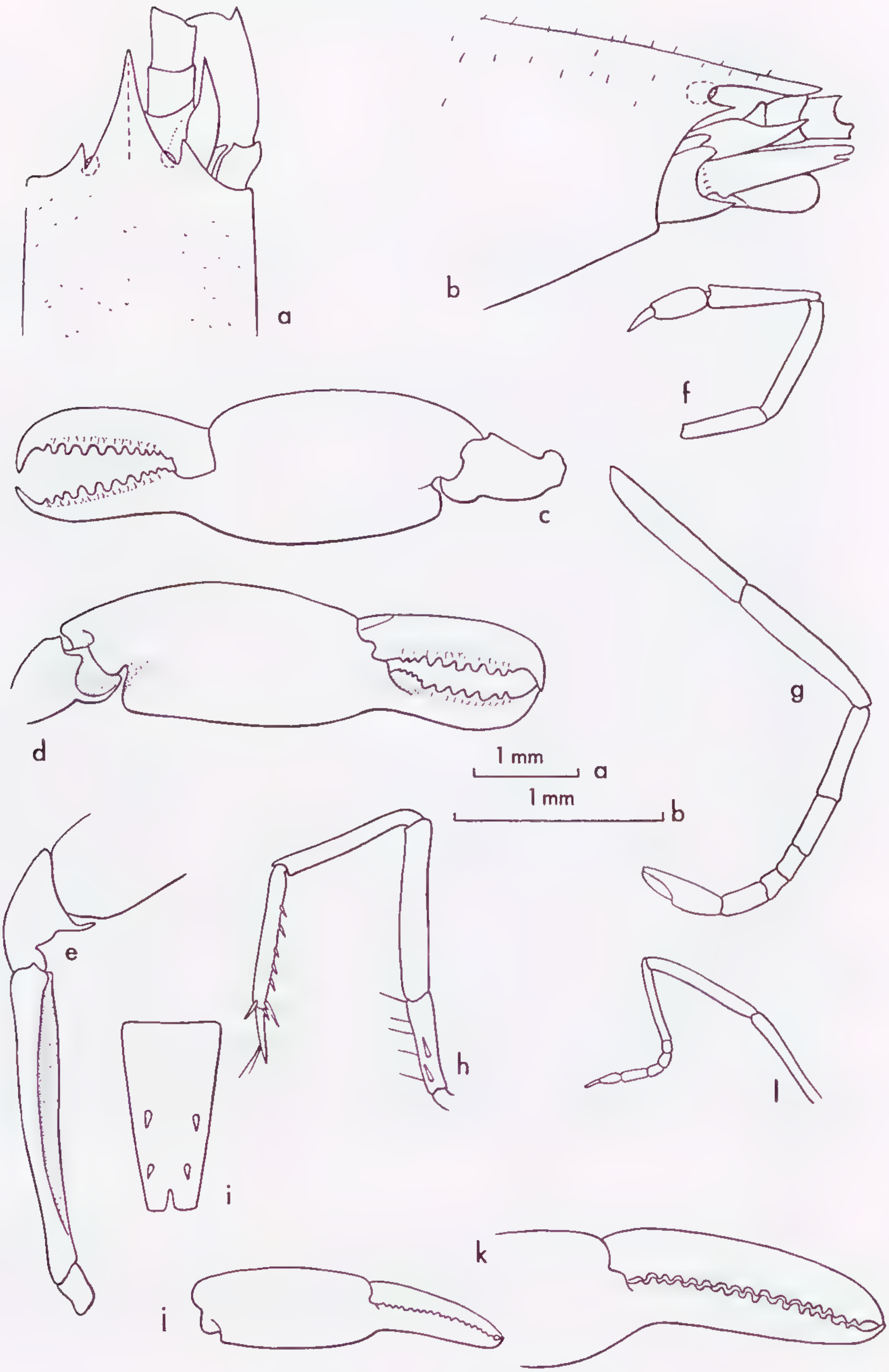

Fig. 94 *Salmoneus sibogae* De Man
14 mm male from Heron Island. **a, b.** Anterior region, dorsal and lateral view; **c, d.** large chela, medial and superolateral face; **e.** merus, lateral face (ischium broken); **f.** small cheliped; **g.** second leg; **h.** third leg; **i.** telson (distal spines missing). 10 mm female from Heron Island. **j, k.** Large chela and enlarged distal region, lateral face; **l.** second leg. All figure scale a, with the exception of k which is scale b.

otherwise noted. We are not certain that these two specimens are of the same species and that either is actually *S. sibogae*. We have examined De Man's holotype and only specimen and found his descriptions and figures to be very accurate; on the basis of the holotype we have identified a series of 15 more or less intact specimens from the Red Sea (not as yet reported upon) as this species.

In general form of the body and appendages both of the Australian specimens resemble each other and conform well both to De Man's holotype and to the Red Sea specimens. In the Red Sea specimens some variation was noted which cover some of the minor differences between the Australian specimens and De Man's specimen — for example in the angle of the inner margin of the orbital teeth which varies from parallel to the axis of the body, as found in the Australian specimens, to lying at an angle to the axis as found in the holotype; also in the slight pubescence of the carapace, which in some Red Sea specimens approaches the condition found in these specimens, and yet others are glabrous.

Our doubts are primarily upon the ratio of the carpal articles of the second legs in the 14 mm male and the large chela of the 10 mm female. In the male the first carpal article of the second legs is only 0.7 the length of the sum of the following articles, instead of equal to or longer than the sum, as in all other specimens including the type and the Red Sea specimens. However, this specimen had only one second leg and that was loose in the vial (but must have come from the specimen as the specimen was alone in the vial); thus, it could have been an anomalous development, possibly even from regeneration. In the 10 mm female the chela was more slender and had more teeth than any other specimen, being 3.8 times as long as broad and bearing about 17 teeth. Most of the specimens, including the Australian male, were 3.0-3.2 times as long as broad and usually carried about 10 teeth, with the most slender specimen among the Red Sea specimens being 3.6 times as long as broad, and another specimen from the Red Sea carrying 14 teeth on the dactylus (but the last three did not meet corresponding teeth on the pollex).

We do not know how to evaluate these differences but suspect that they may lie within extremes of variation in Australian populations. We therefore have assigned these two specimens to this species, but advise future workers to study the range of variation before accepting our determination.

The species can be distinguished from the other known Australian species of *Salmoneus*, *S. tricristatus* Banner (B&B I:334) by the absence of strong keels on the carapace. The records of capture given above do not appear in Appendix II.

BIOLOGICAL NOTES: Most, if not all, of the specimens we have available of this species were collected intertidally; it is a small species, with the largest we have seen being only 16 mm long (from the Red Sea). Dr Bruce's field notes indicate these specimens were of translucent white with an orange "liver"; we reported that the specimens from the Marshall Islands were "usually bright yellow to muddy white in colour while the eggs were red." (1968:270). In the Marshall Islands the specimens were collected under rocks intertidally with worms of the genus *Eurythoe* ("fire worms") and the shrimp *Alpheus strenuus strenuus* Dana and *S. tricristatus* Banner.

DISTRIBUTION: This appears to be a rather wide-spread species in spite of the fact that it has previously been reported only three times, the holotype by De Man from the Lucipara Islands (in the middle of the Banda Sea), and by ourselves from Canton Is. in the Phoenix Group and from Enewetak in the Marshall Islands. However, we have specimens in our present study collections, as yet unreported, from the Philippines, Madagascar and the Red Sea.

ADDITIONAL NOTES

In Part II of this paper (p.341) we listed *Synalpheus haddoni* on the basis of Coutière's record of a species from Torres Straits and expressed a little confusion by his two different names and two different assignments to subgeneric groups. In his earlier publications (1900:411) he named it *S. laevimanus Haddoni,* making the point that it was the first time that this species (or any member of the Laevimanus Group, a group that was to be established later) had been found in the Pacific. In his second publication (1909:10) he raised the subspecies to species level and transferred it to the Biunguiculatus Group. (The group names now have been changed to Gambarelloides and Coutierei Groups, respectively — see B&B, 1975:274). One of the characteristics of the Gambarelloides Group is the presence of a thick brush of setae on the dactylus of the small chela, but this characteristic was not mentioned or figured by Coutière.

We have since had the opportunity to examine the large holotype and the smaller allotype of Coutière's species at the British Museum (Natural History). We found that Coutière's description of the holotype was accurate, but that the specimen lacked the small cheliped. This appendage was found on the smaller allotype, however, and we found it lacked the brush of setae characteristic of the Gambarelloides Group. Therefore, his 1909 assignment was correct. As in our key to the species of *Synalpheus* we had presumed the dactylus carried the tuft of setae (1975:280, dichotomy 17), the placement of the species is incorrect. With this characteristic known, it now keys out to *S. streptodactylus* Coutière under dichotomy 25. These two species can be easily separated as the tip of the telson in *S. haddoni* is very narrow with the longer posterolateral spines almost two-thirds as long as the tip is broad, while the tip in *S. streptodactylus* is broad, almost 2.5 times as broad as the spines are long (contrast fig. 17e and 25g, *op. cit.*).

ADDITIONAL RECORDS (arranged alphabetically)

Alpheopsis trispinosus (Stimpson) (I:337): 1 specimen from TM G1538; 8, WM 94-65; 1, WM 161-65. The range of this species has been extended from southern Australia westward and northward to include Shark Bay, W.A.

Athanas dimorhphus Ortmann (I:313): 1 specimen from JG 6-73; 1, JG 9-73; 2, US 123608.

Athanas dorsalis (Stimpson) (I:324): 2 specimens from AM 460a; 1, WM 98-65; 1, WM 119-65; 1, WM 163-65; 1, 208-65. The range in western Australia has been extended northward to include Exmouth Gulf.

Athanas sibogae De Man (I:321): 3 specimens from UQ 12. The range in eastern Australia has been extended southward to include Moreton Bay, Qld.

Automate dolichognatha De Man (I:299): 2 specimens from US 123609.

Synalpheus carinatus De Man (II:283): 1 specimen from JC 44; 2, JC 50. The range in eastern Australia has been extended northward to Cooktown, Qld.

Synalpheus comatularum (Haswell) (II:289): 2 specimens from JC 43; 2, JC 45; 2, JC 47; 1, JC 51; 3, WM 95-65. The range in eastern Australia has been extended southward to off Cooktown, Qld.

Synalpheus coutierei Banner (II:343): 2 specimens from WM 30-65. The range in Western Australia has been extended southward to include the Dampier Archipelago.

Synalpheus gracilirostris De Man (II:372): 2 specimens from 75 LIZ-L; 2, 75 LIZ-V. This species was previously known from one specimen from Hayman Island, Qld (about 20°S); these came from Lizard Island, Qld. (about 14°40'S).

Synalpheus neomeris (De Man) (II:357): 1 specimen from AM 397; 1, JC 55; 2, WM 226-65. The range in western Australia has been extended northward to Cape Jaubert.

Synalpheus neptunus neptunus Dana (II:317): 14 specimens from WM 60-65; 2, WM 10380.

Synalpheus pescadorensis Coutière (II:301): 1 specimen from 75 LIZ-M. This extends the range northward to Lizard Island, Qld.

Synalpheus quadriarticulatus B&B (II:297): 1 specimen from 75 LIZ-G. This extends the range southward on the Queensland coast to Lizard Island, Qld.

Synalpheus stimpsonii (De Man) (II:292): 1 specimen from AM 443; 2, JC 47; 1, JC 49; 2, JC 53; 2, JC 56; 1, JC 57; 1, WM 79-65; 1, WM 226-65 2, 75 LIZ-14.

Synalpheus streptodactylus Coutière (II:362): 7 specimens from SM 4; 1, WM 97-65; 1, 75 LIZ-1.

Synalpheus tumidomanus (Paulson) (II:377): 4 specimens from AM P. 5276; 1, AM P. 8706; 2, AM P. 13487; 30, BAU 3; 1, BAU 37; 1, TM G1514; 2, TM G1529; 5, TM G1538; 4, VM 32N; 7, VM 33S; 9, VM 41N; 1, WM 176-65; 4, WM 153-176; 2, 75 LIZ-I; 2, 75 LIZ-I; 3, 75 LIZ-Q.

APPENDIX II

ADDITIONAL LOCALITY LISTS FOR ALPHEID COLLECTIONS

The following collections were received after the preparation of the locality list for Part I (1973:353), and contain specimens referred to in Parts II and III. The same alphameric system has been followed and the lists are arranged alphabetically by the key letters. (We should note here and in Part I that in general the date notation, other Americans follow their system of month/day/year, while we and the Australians follow the British system of day/month/year. If the century is not indicated in the year date, it is of the current centry — *i.e.* "/50" is "/1950".)

AQUINAS COLLEGE

AC	1, 3, 4.	Northern reef of island north of Rolland Passage, Easter Group Houtman Abrolhos Island. Coll. M. Yates and J. Unkovich, 30/7/72. From crinoid. Same as above. From coral on shallow reef.
	7	Same as above. From coral on shallow reef.
	15, 16, 17, 18.	North of Leo Island, Easter Group. Coll. M. Yates and J. Unkovich, 31/7/72. From coral reef.
	29, 30, 35.	North of Leo Island, Easter Group. Coll. M. Yates and J. Unkovich, 2/8/72. From coral reef in lumps of dead coral at 6 ft.
	38, 39.	Easter Group. Coll. M. Yates and J. Unkovich, 2/8/72. From crinoid.

The collections listed below were from the North Island in Houtman Abrolhos Islands off Western Australia. They were collected during the Aquinas College Seventh Abrolhos Expedition in 1974 and were collected by P. Bannon and G. Davis with the exceptions of AC 40 which was collected by A. Sasche, and AC 61 and 62 which were collected by P. Bannon, G. Davis and M. Minotti.

AC	40, 42.	Section 7, reef. 5 ft. 27/8/74. Found in coral which was loose on top of reef.
	41.	Same as AC 40. Found in coral rock near reef.
	43, 44.	Same as AC 40. 18-24 inches. Found in loose coral rock.
	45.	Same as AC 43. 6ft.
	46.	Section 4. 10ft. 29/8/74. Found in loose coral.
	48.	Same as AC 46. 30 inches.
	52, 54.	Section 9, 15 ft. 29/8/74. Found in loose coral rock.
	53.	Same as AC 52. 4 ft. found in coral.
	55.	Same as AC 52. 10 ft.
	57.	Same as AC 52. 30/8/74.
	58, 65, 71, 72, 73, 74	Section 9. 3 ft. Found in loose coral rock. Habitat was on slope of a reef which dropped off quickly.
	59, 62, 69.	Same as AC 58. 4 ft. Found in loose coral.
	60, 70.	Section 9. 15 ft. 30/8/74. Found in *Montipora* coral which was still attached to the reef.
	63.	Same as AC 59. 3 ft.
	64.	Same as AC 59. 15 ft.
	66.	Same as AC 59. 1 ft. Found in sponge.
	67.	Same as AC 59. 3 ft.
	68.	Section 9. 9 ft. 30/8/74. Found in loose coral rock. Habitat was on the slope of a reef which dropped off quickly.
	76, 78, 79, 81.	Section 5. 5 ft. 30/8/74. Found on flat bottom in loose coral.
	77.	Same as AC 76. 35 ft.
	82.	Section 8. 20 ft. 31/8/74. Found on side of reef which sloped off sharply. Living in dead coral.
	C-54.	East side of Jubilee Island. Pelsart Group. 4 inches, in coral. 7/1/67.

THE AUSTRALIAN MUSEUM
(See also LIZ listings)

AM	460.	Torres Straits, Qld. Coll. P. C. Black. In weed.
	460a.	Pt. Peron, near Fremantle. W.A. Coll. H. Butler, —/6/59.
	461.	Careel Bay, Pittwater, N.S.W. Coll. P. Hutchings, 11/12/73. From *Posidonia*.
	462, 463.	Same as AM 461. 30/7/73. From *Zostera*.
	464.	Same as AM 461. 27/2/72. In mud, sandy, adjacent to *Zostera* beds.

465. Same as AM 461. 11/12/73.

466. Same as AM 461. 10/6/73. Upper *Zostera.*

467. North Is., Capricorn Group, Qld. Coll. M. Ward and W. Boardman. July 1929.

AM E.4496. South Australia, rec. 1913.

AM P.1542, 3. Port Jackson, N.S.W. Received 1908.

13566. Middle Harbour, Port Jackson, N.S.W. Coll. A. R. McCulloch. Under stones.

17923. Wallis Lake, near Forester, N.S.W. Between Godwin Is. and Wallis Island in Zostera. 2 ft. Coll. W. F. Ponder, K. G. O'Gower and P. Dixon. 17/4/71. Soft mud, in *Zostera.*

19636. South east of Broken Bay, N.S.W. 33°44'S; 151°54-50'E. 225 fms. Coll. N.S.W. State Fisheries on F. R. V. Kapala 1/8/72.

20709. Belmont Beach, north end, near Terrigal, N.S.W. 15 m. Coll. J. Laxton, 18/3/76. Shipek grab.

21599. Off Richmond River Mouth, N.S.W. 28-30 fms. COll. J. C. Yaldwyn on Swains Reef Expedition, 7/10/62. Prawn Trawl.

21872. Tangalooma, Moreton Bay, Qld. Loc: 101(1). Sample 1323. High tide — 2.37 m. Coll. CSIRO, Moreton Bay Survey 5/1/73. Bare Sand.

21873. Tangalooma, Moreton Bay, Qld. Loc: 102B. Sample No. 1324. Coll . CSIRO Moreton Bay Survey, 5/3/73. Among sea grasses, *Halophila ovalis* and *H. spinulosa.*

25161. S. end Coconut Beach, Lizard Is., Qld. Rotenone Station. 2-7 m. Bottom, coral and sand. Collected by Fish Dept. 24/11/75.

27254. Same as AM P. 2006.

27255. Same as AM P. 6354

27256. Same as AM E. 4496.

27257. Same as AM E. 4499.

27258. Same as AM P. 1418.

27259. Same as AM P. 13580.

27260. Same as AM P. 13583.

27261. Same as AM E. 3180.

27262. Same as AM E. 3180.

27264. Same as AM P. 6352.

27407. Same as AM P. 8565.

27408. Same as AM P. 10038.

AM P.27409.	Same as AM P. 10038.
27430.	Same as AM P. 2577.
27431.	Same as AM P. 2577.
27432.	Same as AM P. 2577.
27433.	Same as AM P. 2577.
27434.	Same as AM P. 2578.
27435	Same as AM P. 2579.
27436.	Same as AM P. 2577.
27439.	Same as AM E. 3147.
27452.	Same as AM P. 2006.
27569.	Same as AM P. 7027.
27765.	Same as AM P. 5572.
27766.	Same as AM P. 8028.
27767.	Same as AM P. 7982.
27783.	Same as AM P. 7521.
27789.	Same as AM P. 3566.
27790.	Same as AM P. 3566.
27791.	Same as AM E. 3180.
27874.	Same as AM P. 1418.
27875.	Same as AM P. 2152.
27877.	Same as AM P. 1695.
27878.	Same as AM P. 11730.
27884.	Same as AM E. 4499.
27885.	Same as AM E. 4500.
27936.	Same as AM E. 6274.
28122.	Same as AM P. 7982.
28123.	Same as AM P. 8028.
28124.	Same as AM P. 8028.
28125.	Same as AM P. 14960.
28137.	Same as AM P. 3574.
28155.	Same as AM P. 11882.
28160.	Same as AM P. 4229.
28164.	Same as AM E. 3180.

A. H. AND D. M. BANNER

BAU 63. Wilson River Mouth, Port Macquarie, N.S.W. 2.6 tidal level and above 10/2/64. In very soft muddy sand in eel grass beds. (Note: BAU 64-71, incl. contained no alpheids).

C. R. SMALLEY

CS 37. Exmouth Gulf, W.A. Coll. C. Smalley 22-23/10/70. Trawled, in sponges.

JAMES COOK UNIVERSITY

These collections were made by R. A. Birtles and L. P. Zaan from the School of Biological Sciences. (The data given below for these collections in the two series are all that is presently available).

JC 34. Bowling Green Bay, near Townsville, Qld. 5 m. From *Solenocaulon* sp.

35. From approximately 60 km E. of Townsville, Qld. 40 m. Trawled, from sponge.

36. Halifax Bay, north of Townsville, Qld. From soft coral.

These collections were made by R. A. Birtles and L. P. Zaan from the northern Great Barrier Reef and the Torres Straits.

JC 37. F4. SS004 and SS005. Pelorus on C006. 4/5/74.

38. F5. Wheeler Is. 9/10/74.

39. F6. Lizard Is. 15/11/73. From crinoid.
40. F7. Lodestone Reef. 6 m. 11/1/74.
41. F8. Lizard Is. 25 m.
42. F9. Tijou Reef. 11/11/73. Crinoid 10.
n.b. the numbered crinoids have not yet been identified.
43. SS034. Northwest Reef, Torres Strait. 14 m. On crinoid C036.
44. SS009-010. Tijou Reef. 7 m. On crinoid C034.
45. SS030. Thursday Is. Torres Straits. 76 m. On crinoid C034.
46. 35022-023. Tijou Reef. On crinoid C027.
47. SS036. Northwest Reef, Torres Straits. 14 m. On crinoid C038.
48. SS104-105. Lizard Is. 10 m. On crinoid C000.
49. SS040. Sue Island, Torres Straits. On crinoid.
50. SS025-026. Tijou Reef. 8 m. On crinoid C028.
51. SS031-032. Thursday Is., Torres Straits. 6 m. On crinoid C035.
52. SS027. Thursday Is., Torres Straits. 6 m. On crinoid C033.
53. SS109-110. Lizard Is. 18 m. On crinoid C176.
54. SS072-73. Murray Is., Torres Straits. On Crinoid C076.
55. SS074. Murray Is., Torres Straits.
56. SS118-119. McGilvray Cay, Lizard Is., 20 m. On crinoid C000.
57. SS108. Lizard Is. On crinoid C164.

JOHN GARTH

These collections were made personally by Dr John Garth of the Allan Hancock Foundation, Los Angeles, California while Zoologist in Residence at the University of Queensland, Brisbane. We are prefacing his collection numbers with JG.

JG 6-73. Dunwich, Stradbroke Island, Moreton Bay, Qld. 11/6/73. Collecting on sandy mud flats with well-spaced turnable rocks encrusted with dead oysters at higher level and live mussels at lower level. 0.2 m. tide at 1533. With Stephen Cook.

7-73. Connecting reef between Goat and Bird Islands, Moreton Bay, Qld. 7/5/73. Collecting on sand flats with matted *Zostera*. Turnable rocks, live oysters and mussels, dead coral slabs at lowest level. 0.2 m. tide at 1423. With Stephen Cook from speedboat "Scylla".

9-73. Dunwich, Stradbroke Island, Moreton Bay, Qld. 9/5/73. Same locality as Sta. 6-73. From speedboat "Scylla". 0.2 m tide at 1638. Temperature 75°F. With Stephen Cook and Stephen Newlands.

10-73. Wellington Point, Moreton Bay, Qld. 6/5/73. Collecting along sandy bar leading to a small island, with mud flats on either side having turnable rocks encrusted with oysters and mussels. 0.3 m tide at 1808.

12.73. From S. of jetty on W. side of St. Helena Island, Moreton Bay, Qld. to Beacon off N. point of island. 23/5/73. Dredging from speedboat "Scylla". 1-3 fms. Bottom mud, broken shell, sponge and algae. 0930-1230 hrs. With Stephen Cook.

13-73. Tannum Sands, S. of Gladstone, Qld. 29/5/73. Collecting on rocky reef with sandy substrate. No turnable rocks, but beach rock could be pried apart along cleavage lines. Orange sponge with many small xanthids. 0.2 m tide at 1201.

14-73. Eimeo Beach, N. of Mackay, Northern Qld. 30/5/73. Turnable rocks on sand and cobble substrate at outlet of estuary. 0.5 m tide at 1523.

16-73. Picnic Cove, Magnetic Island, off Townsville, Northern Qld. 2/6/73. Collecting on shore with sandy substrate. 0.0 m tide at 1536. With Shirley Trefz.

17-73 West along S. shore of Jetty, Peel Island, Moreton Bay. 15/6/73. Beach rock with turnable slabs, some rubble, some sandy beach, some dead corals. 0.2 m tide at 1456. With Stephen Cook.

20-73. Brammo Bay, Dunk Island, Northern Qld. 8/6/73. Collected by Shirley Trefz. On and under small granite boulders on mud flats at low tide. *Ocypode* on sand.

21-73. Lizard Is., N. of Cooktown, Northern Qld. 26/6/73. Collecting in lagoon from mangroves and on sand flats with small, turnable oyster-encrusted rocks. 0.5 m tide at 1211. With D. P. Abbott.

22-73. Low Isles, off Port Douglas, Northern Qld. 27/6/73. Collecting on reef flat S. of Sand Cay (with lighthouse). Turnable pieces of dead coral over coral rubble. 0.4 m. tide at 1243. With John Lucas. Additional specimens collected further seaward by Shirley Trefz.

J. E. RANDALL

Personal collections made by Dr John E. Randall, Bernice P. Bishop Museum,

Honolulu, in connection with a study of an alpheid-goby association; specimens speared with a "feather-duster"-type piano wire spear. The collection designations are ours.

JR 1. One Tree Is. 2 m. 1/18/73. Lives with an elongate pale pink barred goby with a small black spot behind the eye.

2. Same locality. Lagoon, 2 m. 1/19/73. Chelae with irregular bands of purple, antennae red.

3. Same locality. 2 m. 1/18/73. Living with yellow green goby, lagoon near patch reef.

4. Same Locality. 1-1.5 m. 1/12/73. Living with *Cryptocentroides maculosus*, a gobiid fish.

9. Same locality. 2 m 1/17/73. Lagoon, near patch reef in vicinity of artificial reefs. Some sand and coral rubble. Caught by hand near burrow.

12. Carter Reef, near Lizard Is., Great Barrier Reef. 60 ft. 6/25/73. Outside reef, rubble and sand. Living with *Cryptocentrus guttatus*, a gobiid fish.

"LIZ" COLLECTIONS
(Australian Museum)

These collections were made by Dr Patricia Hutchings of the Australian Museum from Lizard Island, Qld. (14°40′S: 145°27′E). The alphameric code designations are the registration numbers of the Australian Museum. A description of the types of habitat in which these alpheids were collected will appear in Hutchings and Weate (in press).

75 LIZ 1. Second reef off Station Beach, 8-10 ft. at high tide. 6/1/75. Exposed to N. W. winds. Dead *Pocillopora*, very hard solid reef rock.

3. Transect off point north of Crystal Beach. 35 ft. 4/14/75. Exposed to S. E. winds Habitat with high percentage of live coral.

4. Transect off point to north of Crystal Beach. 60 ft. 15/1/75. Exposed to S. E. winds. Solid reef rock, encrusted with brown algae, soft coral, little live coral and filamentous algae.

7. Reef off Point to north of Coconut Beach. 50 ft. 17/1/75. Solid reef habitat, heavily encrusted with algae etc.

8. Same as above. 20 ft. 17/1/75. Exposed to S. E. winds. Solid with large surface area, heavily encrusted with coralline algae *Lithothamnion*.

14. Pichon's N. E. transect on N. E. face of Lizard Island from slope. 6/1/75. Habitat with high percentage of coral *Diplostrea* sp.

C. Bommie on inner Yonge Reef. 7/1/75. Exposed to N. W. winds. Flat, horizontal plates of what was originally tabular *Acropora*. Habitat of large surface area and easily broken up.

G. Outer Yonge Reef (steep sloping reef from 20-40 ft). 80 ft. 10/1/75. Rich diverse area. Coral rubble covered with algae *halimeda*, but loose rubble in between reef rock. Habitat with high percentage

	of live coral.
75 LIZ H.	Same as above. Habitat with large surface area and easily broken up.
I.	Outer Yonge Reef. 20 ft. 10/1/75. Very little *Halimeda,* mainly coralline algae. Solid reef habitat.
L.	Same as above. 60 ft. 1/1/75. Solid reef habitat with limited algae growth, inside coral cave.
M.	Same as above. 80 ft. 12/1/75. Just outside cave. Habitat with large surface area and easily broken up, with much *Halimeda.*
Q.	Same as above. 10 ft. 13/1/75. Exposed to N. W. winds. Fairly large surface area, but covered with pink coralline algae rather than filamentous algae. Solid reef habitat.
R.	Inner Yonge Reef. Reef flat (very compact, and narrow zone). 6ft. (high tide). 19/1/75. Exposed to N. W. winds. Halfway from reef crest to outer reef. Heavily encrusted with *Lithothamnion,* coralline algae. Habitat with large surface area and easily broken up.
S.	Same as above. Dead Staghorn, heavily encrusted coralline algae, brown and green filamentous algae. Dead branching coral habitat.
T.	Same as above. Flat horizontal cemented, originally table top *Acropora.* Habitat with high percentage of coral.
U.	Inner Yonge Reef—bommie on reef flat. 20 ft. (high tide). 20/1/75. Exposed to N. W. winds. Some coralline algae, alcyonarians, green filamentous algae. Habitat with large surface area and easily broken up.
V.	Same as above. 6 ft (high tide). 20/1/75. Hard cemented *Lithothamnion.* Relatively large surface area, coralline algae and bits of *Halimeda.* Solid reef habitat.

MACLEAY MUSEUM

MM 108.	Cape Grenville, Qld.
260.	Sue Islet, Torres Straits, Qld.

QUEENSLAND MUSEUM

QM W 2241.	Dunwich, Moreton Bay, S. E. Qld. Coll. F. C. Vohra 5/2/62.

SOUTH AUSTRALIAN MUSEUM

SM C 514	Queenscliffe, Kangaroo Is., S. A. Collected by Capt. Brown, 1886.

SHIRLEY TREFZ

Personal collections made by Dr Shirley Trefz, Leeward Oahu Community College, Honolulu, while on leave. The collection designations are ours.

ST 1.	Low Isles, Great Barrier Reef. 5/27/73.

ST 2.		Same locality. 6/11/73.
3.		Dunk Island, Qld. 7/7/73. Under granite rock and on mud flat.

TASMANIAN MUSEUM AND ART GALLERY

The North-West Acid Plant Survey and Wesley Vale Offshore Survey were carried out by the Department of Agriculture, Sea Fisheries Division. The area covered by the North-West Acid Plant Survey lies offshore between Burnie and Penguin, N. W. Tasmania. That covered by the Wesley Vale Offshore Survey lies between Devonport and Port Sorell, N. W. Tasmania.

TM	G1348.	Midway Point, Tasmania. Coll. G. Prestedge, 14/6/71.
	G1349.	Same locality. 5/9/71.
	G1359.	Same locality. 23/10/71.
	G1461.	Western Port, Victoria. Coll. J. R. Penprace, 20/2/72.
	G1482.	Sta. 3 of North-West Acid Plant Survey. 2½ miles off Burnie, Tasmania.
	G1509.	Sta. 7 of Wesley Vale Offshore Survey. N.N.W. of Moorland Point, Tasmania. 7-11/6/71.
	G1510.	Sta. 22 of Wesley Vale Offshore Survey. North of Pardoe Beach, N. W. Tasmania. 10 fms. 7-11/6/71.
	G1511.	Sta. 18. Same as above.
	G1514.	Darlington Beach, Maria Island, Tasmania. Collected by Turner and Dartnall, 16/4/67. In kelp holdfast.
	G1528.	West of Cape Barren Is., Bass Strait, Tasmania. 16 fms. 14/10/50.
	G1529.	Same as above.
	G1538.	Marion Bay, S.E. Tasmania. Collected by Mrs E. Turner and A. J. Dartnall, 6/1/71.

UNIVERSITY OF QUEENSLAND

UQ	35.	27°10′S., 153°21′E. 8 fms. 1/5/72.
	36.	Gulf of Carpentaria 15°23′S., 137°E. Coll. Moore on "Clan Nellie"

NATIONAL MUSEUM OF VICTORIA

The stations below were collected by the Marine Pollution section of the Fisheries and Wildlife Department of Victoria as part of some zoobenthic studies in Western Port Bay. They were taken from the Crib Point area.

VM	Sta. 23N.	Coarse gravel, some sand, much broken shell. 34 ft.
	25N.	Sand, little mud, worm tubes. 36 ft.
	25S.	Sand, mud, broken shell, sponges, etc. 28 ft.
	26S.	Sand, with medium-sized pieces of old shell. 26/2/65. 32 ft.
	31N.	Fine sand and mud. 48 ft.

VM 31S.	Same as the above.
32N.	Sandy gravel. 21/2/69. 38 ft.
32S.	Muddy sand and gravel, some shell. 2/2/69. 43 ft.
33S.	Heavy reef with large stones, sponges, tunicates. 29/10/73. 42 ft.
41N.	Fine gravel and sand with mud, heavy stones, etc. 1965, 1973, 52 ft.

Other Victoria Museum collections:

VM 37.	N.S.W. Coll. Mr Brown, July, 1872.
VM Sta. 918.	Beaumaris, Port Phillip Bay, Victoria. 23/8/71. Sandy sediment. (See VM 924, B&B 1973:376).
Sta. 984.	Sorento, Port Phillip Bay, Victoria. 5 m.24/11/72. With tunicate on sandy substrate. (See VM 924, B&B 1973:376).

WESTERN AUSTRALIAN MUSEUM

WM 287-65.	N. E. side Rosemary Is., Dampier Archipelago. Coll. B. R. Wilson and G. W. Kendrick, 27/8/61.
251-78-32.	Cottesloe. Coll. L. Glauert, July, 1932.
131-76	Cockburn Sound, S.W.A. Coll. A. J. Santich, Feb., 1976.

APPENDIX III

Species of alpheids listed in the literature as from Australia under other than current names

As previously listed	Reference	Present Name	Discussed in
Alpheus alope White	White, 1847:75; Miers, 1874:5	*Nomen nudem*	B&B, 1977:281
A. avarus Fabricius*	Heller, 1865:108; ? Bate, 1888:544	? *Alpheus strenuus* Dana	See footnote
A. comatularum Haswell	Haswell, 1882a:762	*Synalpheus comatularum* (Haswell)	II:289
A. crassimanus Heller	Bate, 1888:554	*Alpheus lobidens* de Haan	III:252
A. crinitus Dana	Coutière, 1900:413	*Alpheus bucephalus* Coutière	III:120
A. doris White	White, 1847:75; Miers, 1874:5	*A. strenuus strenuus* Dana	B&B, 1977:281
A. doto White	White, 1847:75; Miers, 1874:5	*A. socialis* Heller	B&B, 1977:282
A. galathea White	White, 1847:75; Miers, 1874:5	*Nomen nudem*	B&B, 1977:282
A. gracilidigitus Miers	Nobili, 1899:233	*A. pacificus* Dana	III:217
A. insignis Heller	? Nobili, 1899:233	*A. diadema* Dana	III:140
A. laevis Randall	Heller, 1865:107; Haswell, 1882b:191	*A. lottini* Guérin	III:65
A. neptunus White	White, 1847:74; Miers, 1874:4	? *A. edwardsii* (Audouin)	B&B, 1977:280
A. paraculeipes Coutière	Green, 1972:67	*A. spongiarum* Coutière	III:116
A. rapax miersi	Coutière, 1898d:166	*A. miersi* Coutière	III:168
A. richardsoni Yaldwyn	Yaldwyn, 1971:88	*A. euphrosyne richardsoni* Yaldwyn	III:235
A. thetis White	White, 1847:75; Miers, 1874:5	*A. lottini* Guérin	B&B 1977:282
A. ventrosus Milne-Edwards	Coutière, 1900:413; Patton, 1966:282; McNeill, 1968:15	*A. lottini* Guérin	III:65
Betaeus trispinosus Stimpson	Stimpson, 1861:32; Haswell, 1882b:192; Whitelegge, 1889:224	*Alpheopsis trispinosus* (Stimpson)	I:337
Betaeus microstylus Bate	Bate, 1888:566	*Alpheus microstylus* (Bate)	III:319
Cheirothrix parvimanus Bate	Bate, 1888:533	*Batella parvimanus* (Bate)	III:16
Crangon bucephalus var. (Coutière)	Rathbun, 1914:654	*Alpheus bucephalus* Coutière	III:120
C. edwardsii (Audouin)	Rathbun, 1914:654; Hale, 1927b:308 Pope, 1949:327	*A. edwardsii* (Audouin)	III:270
C. novae-zealandiae (Miers)	Hale, 1927a:47; 1927b:308	*A. novaezealandiae* Miers	III:145
C. praedator (De Man)	Hale, 1927a:47; 1927b:308	*A. bidens* (Olivier)	III:136
C. strenuus (Dana)	Pope, 1949:326	*A. strenuus strenuus* Dana	III:225
C. villosus (Olivier)	Hale, 1927a:46; 1927b:407; 1941:265	*A. villosus* (Olivier)	III:49
Ogyris mjöbergi Balss	Balss, 1921:7	*Ogyrides mjobergi* (Balss)	III:294
Palaemon bidens Olivier	Olivier, 1811:663	*Alpheus bidens* (Olivier)	III:136
P. brevirostris Olivier	Olivier, 1811:664	*A. brevirostris* (Olivier)	III:170
P. diversimanus Olivier	Olivier, 1811:663	*A. villosus* (Olivier)	III:49
P. villosus	Olivier, 1811:664	*A. villosus* (Olivier)	III:49

APPENDIX III, continued

Paralpheus diversimanus (Olivier)	Bate, 1888:568	*A. villosus* (Olivier)	III:51
Synalpheus bakeri stormi De Man	Hale, 1941:265	*Synalpheus fossor* (Paulson)	II:335
S. biunguiculatus (Stimpson)	Ortmann, 1894:14; Coutière, 1900:411	*S. coutierei* Banner	II:343
S. brucei Potts	Potts, 1915:76; Clark, 1921:624	*S. stimpsonii* (De Man)	II:292
S. falcatus Bate	Bate, 1888:574	*S. comatularum* (Haswell)	II:289
S. laevimanus haddoni Coutière	Coutière, 1900:411	*S. haddoni* Coutière	II:341
S. latastei Coutière	Coutière, 1909:26 (listed with question)	(Evidently in error)	II:278
S. macculochi Coutière	? Coutière, 1908a:13; Hale, 1927a:48; 1927b:308	*S. tumidomanus* (Paulson)	II:377
S. neomeris pococki Coutière	Coutière, 1898d:167	*S. pococki* Coutière	II:366

*It should be noted that Heller in 1865 (p. 108) reported *A. avarus* from Sydney Harbour without further description or figures; he cited *A. strenuus* Dana as a synonym. Except for Bate *(loc. cit.)* who attempted to place a number of presently accepted species in synonymy with *A. avarus*, Fabricius' name has been almost unused in the last century (it was used by Heilprin, 1889a, b, and Gee, 1925) as the original description is faulty and without figures and the type specimen is evidently lost. While the name is still available it is a *nomen dubium* and probably should be officially suppressed; however, according to Holthius (1955:89) *A. avarus* is the type species for the genus. Heller's reference to Dana's work indicated his specimen belonged to the Edwardsii Group at least and possibly is the species presently recognized as *A. strenuus* Dana.

APPENDIX IV

ZOOGEOGRAPHIC SUMMARY

Distribution of alpheids and ogyridids in the faunal provinces of Australia.

In their summary of distribution and relationships of Australian decapod crustaceans, Griffin and Yaldwyn (1968:164) showed that these crustaceans could be divided into two major groups on the basis of their distribution: the tropical species of northern Australia and the temperate species from southern Australia. They reported that the two faunas met and overlapped along the east and west coasts. We have found the same type of division. However, as a device to separate better the distributional patterns we have used the zoogeographic provinces used by other authors (for a review, see Endean, 1957:234). The provinces are:

Solanderian: The cleaner waters of the Great Barrier Reef and most non-continental islands associated with it from the western edge of the Torres Straits (set at 141°30′E) to the Queensland-New South Wales border (at 28°S) (for convenience, 2° further south than the limit of Endean).

Banksian: The more turbid waters along the continental margins and the close-in continental islands within the same limits as the Solanderian Province; we have included in this province the islands of the Torres Straits.

Peronian: The temperate waters from 28°S along the southeast coast of Australia to the Bass Straits and eastern Tasmania; the westward limit we have set at 146°E.

Flinderian: Western Tasmania and the western section of Bass Straits (from 146°E) along the south coast of Australia and up the west coast to about Geraldton, with the limit set at 29°S.

Dampierian: Along the west, northwest and north coasts of Australia from 29°S. to west of the Torres Straits, 141°30′E.

We should caution that our distinction between the Solanderian and Banksian provinces is dulled by the lack of specific information on many of the older museum specimens for their locality labels would merely state "Cooktown, Qld." or "Cairns" and not state whether the specimens were collected along the shores or from off-shore reefs. Another lack of precise distinction lay in the continental islands like the Whitsunday Group which are definitely continental islands in the Banksian province, but in places have reefs similar to those found in the Solanderian province. Because of this confusion of labels and zones, some Solanderian species may have been added to the Banksian lists, thereby making that province by our figures the richest in number of species (fig. 94).

As shown by Griffin and Yaldwyn *(op. cit.)* and as pointed out in the following discussion, the arbitrary delimitations of the provinces are not recognized by the species themselves, and a typical Peronian species may invade the southern Banksian province and *vice versa*. What is actually found, then, is a broad zone of mixing between the adjacent provinces rather than a sharp line.

We should remind the reader that the coasts of Australia are not uniformly sampled, with the bulk of collections being in areas where active research units exist, for example around Heron Island in the Solanderian province, Brisbane in the Banksian, Sydney in the Peronian, and Melbourne and Perth at the margins of the Flinderian. From our records it appears that the Dampierian province has been visited largely by special expeditions or occasional itinerant individuals, and that almost no collections have been made at all in the Great Australian Bight that covers so much of the Flinderian province.

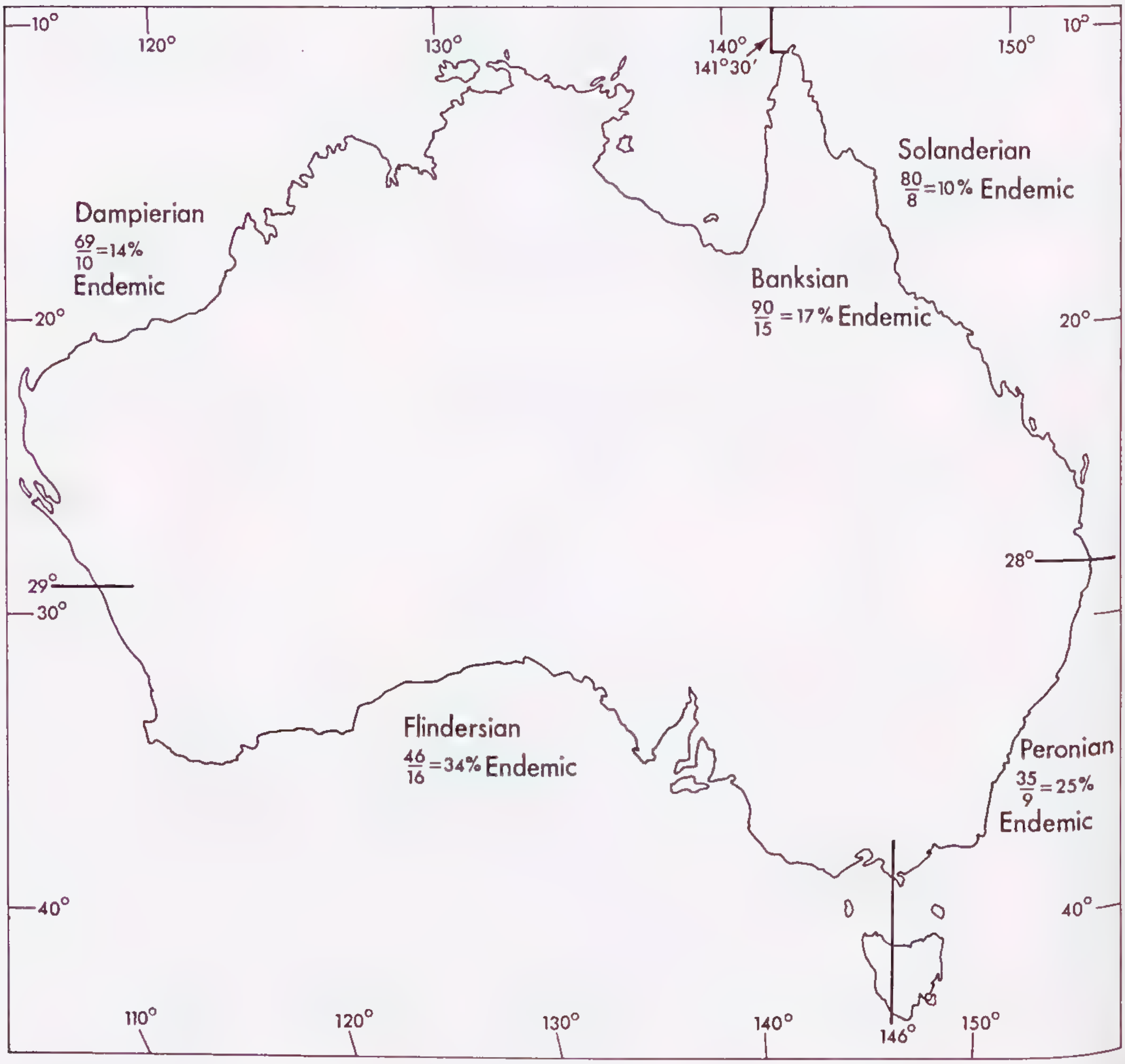

Fig. 95
Australia (sinusoidal projection), showing faunal provinces and percentages of endemism of alpheid and ogyridid shrimp. The location of the boundaries is discussed in the text, as well as the distinction between the Solanderian and Banksian provinces; in the figures, the numerator is the total number of species reported for the province, the denominator is the total number of endemic species found in the province, and the quotient is the percentage of endemism.

Finally, in fig. 95 and Table 8, we have treated the subspecies found in Australia as equal to the species, have considered the unnamed form *Alpheus* sp., as a separate species, and were forced to leave out *A. brevirostris* (Olivier) because there is no indication as to where it was collected in half the perimeter of Australia (see p.226). The two species of *Ogyrides* are also included in the computations.

As to be expected, the tropical fauna is best found in, but not confined to, the Dampierian, Solanderian and Banksian provinces. Many species penetrate further south than the Tropic of Capricorn. Along the east coast we find species especially of the Banksian province, which are species typically not associated with coral reefs, reaching as far south as Sydney, N.S.W. The limits of the tropical fauna on the west coast are more difficult to delimit both by the lack of large numbers of collections, and by the lack of extensive coral reefs. However, as we found that 7 tropical species had reached the Houtman Abrolhos slightly north of 29°S, these islands should be near the zone of transition. This is further north than Griffin and Yaldwyn found for the majid crabs *(op. cit.*, map 1*)*. The large number of species shared by the Solanderian, Banksian and Dampierian provinces (see Table 8) would indicate that if the same habitats were found in the three provinces, they could be expected to have much the same species composition.

The temperate fauna of the Peronian and Flinderian provinces have many fewer species (fig. 94) and like the tropical fauna, many of these species reach into the adjacent parts of other provinces. For example, a number of species that appear to have arisen in the temperate fauna and are endemics (see below) reach up to Moreton Bay in the east and to Shark Bay in the west; two species, at least, reach from the south to the Gulf of Carpentaria.

Faunal Affinities and Endemism

As Griffin and Yaldwyn found for all decapods, almost all species found in the Dampierian, Banksian and Solanderian provinces are of Indo-Pacific relationship, with 101 of the 142 species and subspecies tabulated appearing elsewhere in the Indo-Pacific tropics. The group listed as "Indo-Pacific" included only those which were known to occur both in the Pacific north or east of Indonesia and in the Indian Ocean; the number of species in this group is likely to increase when more extensive collections are made in the western Pacific that are comparable to the collections made from the Maldives and Laccadives in the Indian Ocean. The number of species shared only between Indonesia and Australia is what one would expect considering, first, that most zoogeographers have found the great shallow-water triangle between Indonesia and the southern Philippines to be the richest area in species in the entire Indo-Pacific with many species that apparently have not spread far from the triangle, and, second, considering that the Indonesian shelf area is bridged by a tight island chain to the shelf area between New Guinea and northern Australia.

Some of the non-Australian distributional patterns shown in Table 8 and listed in the text under the distribution of each species appear to be sharply discontinuous. However, the discontinuities may be those of collection, not distribution. For example, the species shown as shared alone between Japan and the Dampierian province is *Athanas japonicus* Kubo, a species that was collected intertidally under rocks on mud-flats in southern Japan and in a mangrove swamp near Darwin, N.T. We are quite certain that if similar habitats were searched in the Philippines and Indonesia, the species would also be found there.

We also believe that the large number of apparent endemics in the tropical waters of Australia is also a reflection of the intensity of collection. Most appear in the extensive Australian collections as a single or several specimens; presumably if collections as exhaustive were made elsewhere in the Indo-Pacific, these species might be found there

Table 8. Faunal Relationships of Australian Alpheids and Ogyridids.

General Distribution \ Australian Distribution	Total Number of Species	Solanderian	Banksian	Peronian	Flinderian	Dampierian	Sol + Banks	Sol + Per	Sol + Damp	Banks + Per	Banks + Damp	Per + Flind	Flind + Damp	Sol + Banks + Flind	Sol + Banks + Damp	Banks + Per + Flind	Banks + Flind + Damp	Per + Flind + Damp	Sol + Banks + Flind + Damp	Sol + Banks + Per + Damp	Sol + Per + Flind + Damp	Banks + Per + Flind + Damp	All Zones
ENDEMIC	36	4	7	1	8	4	2			2	1	2	1					1				3	
NON-ENDEMIC																							
New Zealand only	4			1						1						1							1
Indonesia only	14	1	4				1				2		1		2			1	1				1
Indonesia & Indian O.	14	1	1				1	2			3					1	1		1				3
Indonesia & W. Pacific O.	2														1				1				
Indonesia & Pacific O.	6	1					2							1	1								1
Indian O.	4	1				1					1												1
Japan only	1					1																	
Pacific O.	2	2																					
Indo-Pacific	52	9	2			3	9		2	1	2			1	11				3	2	1	1	5
Indo-Pacific & E. Pacific	3	1																					2
Circumtropical	4	2													1								1
TOTAL NON-ENDEMIC	106	18	7	1	0	5	13	2	2	2	8	0	1	2	16	2	1	1	6	2	1	1	15
TOTAL SPECIES	142	22	14	2	8	9	15	2	2	4	9	2	2	2	16	2	1	2	6	2	1	4	15

as well. An excellent example is the rare *Prionalpheus triarticulatus* B&B — it was until now "endemic" to the Fijian Archipelago, but if that sole specimen from Fiji had not been captured, the two specimens from Lizard Island on the Great Barrier Reef would have been "endemic".

It is quite different with the endemics of the southern Australian waters. All except *Betaeus australis* Stimpson appear to be derived from tropical forms moving into colder waters, finding new ecological niches and being modified to suit these niches. Some of these modifications are great enough that we can recognize them as separate species or subspecies. Thus did the widespread Indo-Pacific *Synalpheus neptunus* (Dana) give rise to *S. n. germanus* B&B found only in the Flinderian province, and the even more widespread *Alpheus strenuus* Dana gave rise to *A. s. cremnus* B&B that is found in all Australian provinces except the Solanderian. We suspect there are other modifications, possibly minor in morphology, but greater in ecological requirements, behaviour and physiology, to be found in the large group of nominal species that penetrate far south of their normal coral reef habitats. These subtle changes may in the future be recognized as a basis for the specific separation of the temperate from the tropical races.

None of the species of alpheids save *Betaeus australis* appear to show relationship to other southern temperate faunas, although these faunas are poorly known (for New Zealand, see below). The exact affinities of *B. australis* are uncertain, but the members of the genus are typically temperate water forms in both the northern and southern hemispheres (the species that De Man named *Betaeus indicus* from Indonesia has been placed by Yaldwyn (1971:88) in his new genus *Betaeopsis*). Species from the genus have been reported both from southern South America and southern Africa; inasmuch as we have seen none of these southern species, we cannot postulate possible relationships.

The invasion of temperate waters by tropical species has given rise to the greatest regional endemism found for the family anywhere. Table 8 shows that all eight of the species found only in the Flinderian province are endemic, and of those confined to the Peronian and Flinderian provinces, 11 of the 12 are endemic. For the total Australian alpheid fauna, the figure is 25 per cent endemism, but as we pointed out above, we have doubts about the true endemism of some tropical species. In contrast, in Hawaii which is not contiguous with the other Indo-Pacific fauna as is southern Australia, but separated by about 3000 km of ocean from the closest archipelagoes, only 24 per cent of the species appear to be endemic (and that includes deep water forms that were not searched for elsewhere).

No definitive studies have yet been published of the New Zealand alpheids, but at least 4 species are endemic to Australia and New Zealand (thus, if these are lumped with the endemics confined to Australia alone, the total number of non-endemics is decreased to 102 and the number of endemics increased to 40). Two of these are confined to the Peronian and Flinderian provinces, one penetrates as far north as Moreton Bay, Qld., and one occurs in all Australian provinces.

The collections from Norfolk and Lord Howe Islands are too small to justify any conclusions, but the few species we have seen from the two islands are interesting. Eight species have been found on the two islands, 6 of which are Indo-Pacific species with wide distribution in Australia; of these 6, only one was collected from both islands, 3 were collected from Lord Howe alone and 2 from Norfolk. The other two species are among those endemic to the Australian-New Zealand waters: *A. socialis* Heller is known in Australia only from the Peronian province, while the other, *A. novaezealandiae* Miers, is found in all Australian provinces.

APPENDIX V

ERRATA

The following errors have been detected in the previously published portions; the errors and corrections are underscored.

Part I

P. 298. Change diagnosis of Family Alpheidae dealing with the mandible to read "Mandible with molar and incisor process except in *Prionalpheus* and with palp of two articles except in *Prionalpheus* and *Batella*".

P. 304. In dichotomy to "*A. dorsalis* (p. 327)" should read "p. 324".

P. 316. The correct spelling of "*Athanas haswelli*" is "*A. hasswelli*" (cf. III: 132. fn.).

P. 326. *A. mascarinicus* line 2 should read *A. mascarenicus*. Under *Biological notes,* the reference "Hipeau-Jacquotte, 1965:47" should read "1965:247".

P. 327. Under *Specimens examined,* the reference "RG451" should read "RG 541".

P. 330 et seq. *Aretopsis aegyptica* should read *Aretopsis aegyptiaca.*

P. 337. The reference in synonymy, "*Alpheopsis trispinosus* Coutière . . . 3:382" should read ". . . 2(8):382".

Footnote. The name "*A. garrick*" should read "*A. garricki*".

P. 352. Under *Biological notes, Galexia* should be spelt *Galaxea.*

P. 355. Under AM 22, eliminate the last statement, "Commensal on urchin *Heliocidaris tuberculata.*"

P. 357. Under AM 156, "Same as AM 43" should read "AM 13".

P. 358. Under AM 177 "Cape Varquar" should read "Cape Farquar".

P. 362. Under AM 439, "Same as AM 103" should read "AM 13".

P. 363. AM P. "2071-2" (listed below AM P.3014) should read "3071-2".

P.365 AM P. "8565-67, 77" should read "8565-67, and 8677". Collecting information the same for all numbers.

Part II

P. 292. The correct spelling of "*Synalpheus stimpsoni*" is "*S. stimpsonii*" (cf. III:132,fn.)

P. 295. Table 2. Due to inadvertant error, the last 5 lines from Table 3 (p. 339) were copied instead of the correct 3 last lines of Table 2. Printed on the following separate page is a full and correct Table 2; it is recommended that this be removed and placed over the erroneous table in Part II, p. 295. (Table 3 is correct as printed.)

P. 326. "*S. triunguiculatus* Paulson" in the third paragraph should read "*S. triunguiculatus* (Paulson)".

P. 341. Under the paragraph entitled "Original description, our translation:" line 18 from top should read "the carpocerite, on the typical specimens . . ." instead of "the antennular peduncle, on the typical specimens . . ."

P. 362. Under *Specimens examined,* citation "WM 94-65" should read "97-65".

P. 369. *Synalpheus prolificus* should read *Alpheus prolificus.*

P. 389. Add to dichotomy 3(2) "Distosuperior margin of merus . . ."

Corrected Table 2, for insertion in Banner and Banner 1975. The Alpheid Shrimp of Australia, Part II: The genus Synalpheus. Rec. Aust. Mus. 29(12):295

Table 2. Species reported in the *S. stimpsonii* complex

Characteristic	*S. stimpsonii*	*S. amboinae*	*S. brucei*	*S. striatus*	Australian species
Tip of rostrum to second antennular article	To middle	Slightly past end	To end	To end	From distal quarter of first to beyond end of second
Length, orbital teeth to rostrum	0.3	Less than half	0.3	0.4	0.3-0.6
Length, orbital teeth to first antennular article	To middle	Past middle (De Man)	To middle	To middle	From middle almost to end
Length, visible part first antennular article to following articles	Longer than sum of following	Equal to sum of following	Same as S *stimpsonii*	Same as S. *amboinae*	Length of first varying with angle it makes to carapace
Tip of stylocerite to antennular article	End first	Same	Same	0.3 of second	From shorter to definitely longer than first
Relative length, teeth of basicerite	Teeth subequal	Inferior markedly longer than superior	Same as S. *amboinae*	Same as S. *amboinae*	Varying from condition in *S. stimpsonii* to condition *S. amboinae*
Length, carpocerite to antennular peduncle	Reaching to end	Same	Same	Same	A little shorter to a little longer than antennular peduncle
Length, squame to antennular peduncle	Equal	Slightly longer	Same as S. *amboinae*	Same as S. *amboinae*	From slightly shorter to slightly longer (lateral spine always longer, incurved or not)
Tooth above dactylar articulation, large chela	Slight	Slight	Absent	Slight	From strong and acute to absent; most slight to moderate
Length-breadth ratio large chela	3.5	3.3	3.2	3.2	2.8-3.6

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*The actual date of publication does not always correspond to the official date used on the volume and in library cataloguing. Thus, our paper in *Pacific Science* 29(4):423-437 bears the date of the volume for 1974, but the next issue of the journal states that vol. 29 no. 4 was actually published under the definition by the *International Code of Zoological Nomenclature* in May, 1975. As the priority of names under the code and the actual date of publication is of primary importance, we have used this date where we have had evidence that it differs from the volume date; however, to facilitate the search for publications in libraries, we have included the volume date in parenthesis — thus, the case cited would be 1975 (1974). We discover at this time (October, 1977) that we have not been consistent in using the actual date of publication either in this now completed manuscript of Part III or in our previous publications, and we regret the confusion that will arise for future workers caused by differences in the texts between the cited dates in the texts and the two dates given in this bibliography.

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The following article has appeared while this paper was in press. It is cited as it contains the records of alpheids from the Philippine which are given as unpublished in the three parts of the Australian study: Banner, D. M. and A. H. Banner, 1979 (1978). Annotated checklist of alpheid and ogyridid shrimp from the Philippine Archipelago and the South China Sea. *Micronesica,* 14(2): 215-257.

INDEX TO NAMES OF ALPHEIDS AND OGYRIDIDS
in
Parts I, II, III

The index gives current and previous names cited in the text and tables, but only for the families Alpheidae and Ogyrididae; the page indicated in bold face gives the description or definition or its citation in a key; the subspecific and varietal names are listed only under the name of the nominate species. The Roman numerals refer to the part number and *fn.* to footnotes.

INDEX TO PLANTS AND ANIMALS

REPORTED TO BE ASSOCIATED WITH ALPHEID SHRIMP

In many cases the shrimp is reported to be associated with "a sponge" or "a crinoid", etc. so in addition to listing the associate under its scientific name, when available, we have also listed the references collectively, by phyla if plants, and by classes if animals. We have also indicated these broader groups after the scientific names for those unfamiliar with the taxon. In a few cases we have used English common names as well, as for "eel grass" and "living coral".

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Supplement I

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SUMMARY

A new species, *Alpheus brucei,* in the Sulcatus Group, is described from Heron Island, Queensland, on the Great Barrier Reef.

INTRODUCTION

The following species was received too late for its description to be included in the foregoing paper, so it is being issued as a separate supplement.

Alpheus brucei sp. nov.

Fig. 1

HOLOTYPE: 24 mm ovigerous female from Heron Island reef flat, at 0.5 m, from a head of *Porites andrewsi* Vaughn. Collected by A. J. Bruce, 1/9/78.

DIAGNOSIS: Rostrum acute, 3.4 times as long as broad at base, reaching to end of first quarter of second antennular article, with rounded carina extending posteriorly well behind corneas. Orbitorostral grooves rounded, broad and moderately deep, eyehoods moderately inflated. Anterior margin of orbital hoods bearing teeth 0.3 as long as rostrum and directed slightly inwards. Margin between orbital teeth and rostrum extended as convex, flattened prominences that curve deeply at base of rostrum. Eyestalk bearing rounded, finger-like process that in lateral view juts out beyond margin of carapace and reaches to level of middle of orbital teeth in lateral view, but is concealed by orbital teeth in dorsal view; distal portions of process bearing short setae. First 2 antennular articles nearly equal in length, third a little shorter, second article 1.7 times as long as broad. Stylocerite with acute tip reaching to middle of second antennular article. Scaphocerite with lateral margins straight, lateral tooth extending just past end of antennular peduncle but well beyond squame; squame narrow, not reaching end of antennular peduncle. Carpocerite as long as lateral tooth of scaphocerite. Basicerite with acute tip of tooth reaching past end of first antennular article.

Ratio of third maxillipeds: 10:3:5. Inferointernal margin of first article terminates in a small acute tooth. Tip of third article bearing tuft of long hairs.

Large chela slightly compressed, 3.7 times as long as broad with fingers occupying the distal third. Surface smooth and bearing only sparse setae. Palm bearing strong, well-developed transverse groove proximal to the dactylus. Dactylus high, laterally compressed, superior surface a rounded carina, tip broadly rounded; plunger low, truncate. Both fingers with oppositive faces distal to plunger and socket developed into thin knife-like ridges that shear when fingers close. Merus 2.2 times as long as broad; superior margin

projecting as strong, acute and curved tooth, inferointernal margin terminating in similar tooth and bearing proximally a few rounded protuberances, each bearing a slight seta; inferoexternal margin distally without tooth but with a slight rounded terminal extension.

Small chela 5.2 times as long as broad with fingers slightly longer than palm; surfaces smooth without sculpturing and with only scattered hairs. Palm bearing acute tooth medial to dactylar articulation, small rounded protuberance lateral to articulation. Medial edge of dactylus developed as knife-like ridge, shearing past corresponding ridge to fit into narrow well-defined groove on propodal finger when chela is closed; ridges best developed in distal half, except just proximal to curved tips where dactylar ridge crosses over propodal ridge from groove, allowing tip to lie on medial side of propodal tip. Merus almost 3 times as long as broad; superior margin terminating in small, curved tooth; inferointernal margin bearing protuberances, 3 of which bear short articulated spines, the others stiff setae and terminating in low angular tooth; inferoexternal margin smooth and with slight terminal projection.

Ratio of carpal articles of second leg: 10:5:3:3:5.

Ischium of third leg armed with spine. Merus unarmed, 5.3 times as long as broad. Carpus half as long as merus, terminating distally in slight rounded projections. Propodus 0.8 as long as merus, bearing on its inferior margin 7 slender spines and a pair distally, superior margin bearing several long fine hairs. Dactylus 0.3 as long as propodus, simple but bearing on its superior margin two-thirds of distance from tip a small patch of setae.

Telson 2.1 times as long as posterior margin is broad. Posterior margin only slightly arcuate, inner spine of posterolateral pair 0.3 as long as posterior margin is wide, outer spine about half as long as inner; first pair of dorsal spines placed anterior to middle. Diaeresis of outer uropod scalloped, external spine dark brown.

Colour notes (from a colour transparency, taken in life from dorsal view by A. J. Bruce): Two broad dark brown bands, at times tinged with dark red, run dorsally the entire length of body from antennular and antennal basal articles and margins of scaphocerite to sixth abdominal segment and the anteriormost portion of the telson. These bands are separated mid-dorsally with a translucent band starting between eyes and terminating in the middle of the sixth abdominal segment; in the posterior portion of the carapace the yellow-orange ovaries can be seen, and in portions of the abdomen the intestine is visible. The orbital hoods and the portion of the carapace posterior to them is transparent, but surrounded on either side with the dark bands. The telson immediately posterior to termination of the coalesced bands, and the proximal ends of the uropods, have a narrow transverse band of similar transparency, but the entire caudal fan beyond is of the same colour as the longitudinal bands; outer spine of outer uropod possibly slightly darker than band and proximal to this spine is a small area near the margin of a dark red. Both of the chelae have a pink to almost purple cast with the fingers being darker and somewhat yellowed. The meri of the chelipeds and the thoracic legs are light pink. The lateral portions of the body are not visible in the transparency. (In nine months of alcoholic preservation the dark bands have faded to a dusty pink and there is no indication of colour on the lateral sides of the carapace or abdomen; however, the eggs have a slight pink cast and the spine on the outer uropod remains dark brown, almost black).

The species is named in honour of its collector, A. J. Bruce, Director, Heron Island Research Station, who has lent us many specimens and been most helpful in our work. The holotype will be placed in the Australian Museum.

DISCUSSION: The shape of the anterior portion of the carapace, the shape of the large chela and the dark spine on the outer margin of the uropods place this species in the Sulcatus Group. Within the Sulcatus Group it is related to the Indo-Pacific species that have teeth on the orbitorostral margin, no teeth on the merus and a simple dactylus on the third legs. These

include *A. facetus* De Man, 1908, 1911; *A. splendidus* Coutière, 1897; *A. edmondsoni* (Banner) 1953 and *A. supachai* Banner and Banner 1966. It is separated from all four species by two characteristics: the transverse groove on the large chela and the large finger-like process on the eyestalk. Within the Sulcatus Group, the presence or absence of a transverse groove on the large chela appears to be a firm characteristic within the species, and to our knowledge is not variable. The other four related species have a process on the eyestalk (called a *"saillie epineuse"* by Coutière and labelled in the drawings of his *Theses* as *"epc"* — 1899;112, Fig. 98 and elsewhere), but in all it is low, thicker and rounded, and never extends so far anterior to the carapace. Other characteristics also separate this species from the latter three: *A. splendidus* bears its orbital teeth on the curvature of the orbital hoods, superior to the anterior margin itself, rather than as a projection of the margin; both *A. edmondsoni* and *A. supachai* lack of the shelf-like projection of the margin of the carapace between the orbital hoods and rostrum, as found in this species.

However, except for the characterisitics of the large cheliped and the size of the extracorneal process, this specimen is almost identical with *A. facetus*. In *A. facetus* the palm of the large cheliped bears on the more proximal portions of the superior surface two longitudinal ridges with a shallow groove between and no vestige of a transverse groove, and the inferointernal margin of the merus bears short spines; however, the development of spines on the merus is variable. Usually the spine at the articulation of the outer uropod is colourless in *A. facetus*, but it may be brown or black. The colour pattern of the two species is quite similar, as well. Notes on the collections of the two species are not sufficiently detailed to indicate any ecological separation.

This species may be inserted in our key to the species of *Alpheus* (Banner and Banner, 1981) by inserting a new couplet under dichotomy 12:

12.(11) Large chela with consipicuous transverse groove proximal to dactylar articulation; with the abrupt sides of groove lying at right angles to surrounding palmar margins. .... *A. brucei*

Large chela either without any indication of transverse groove, or with shallow transverse depression; with margins of depression confluent with surrounding palmar margins. 12a

The present couplet 12 then should be renumbered 12a.

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Manuscript accepted for publication 13 November, 1978.

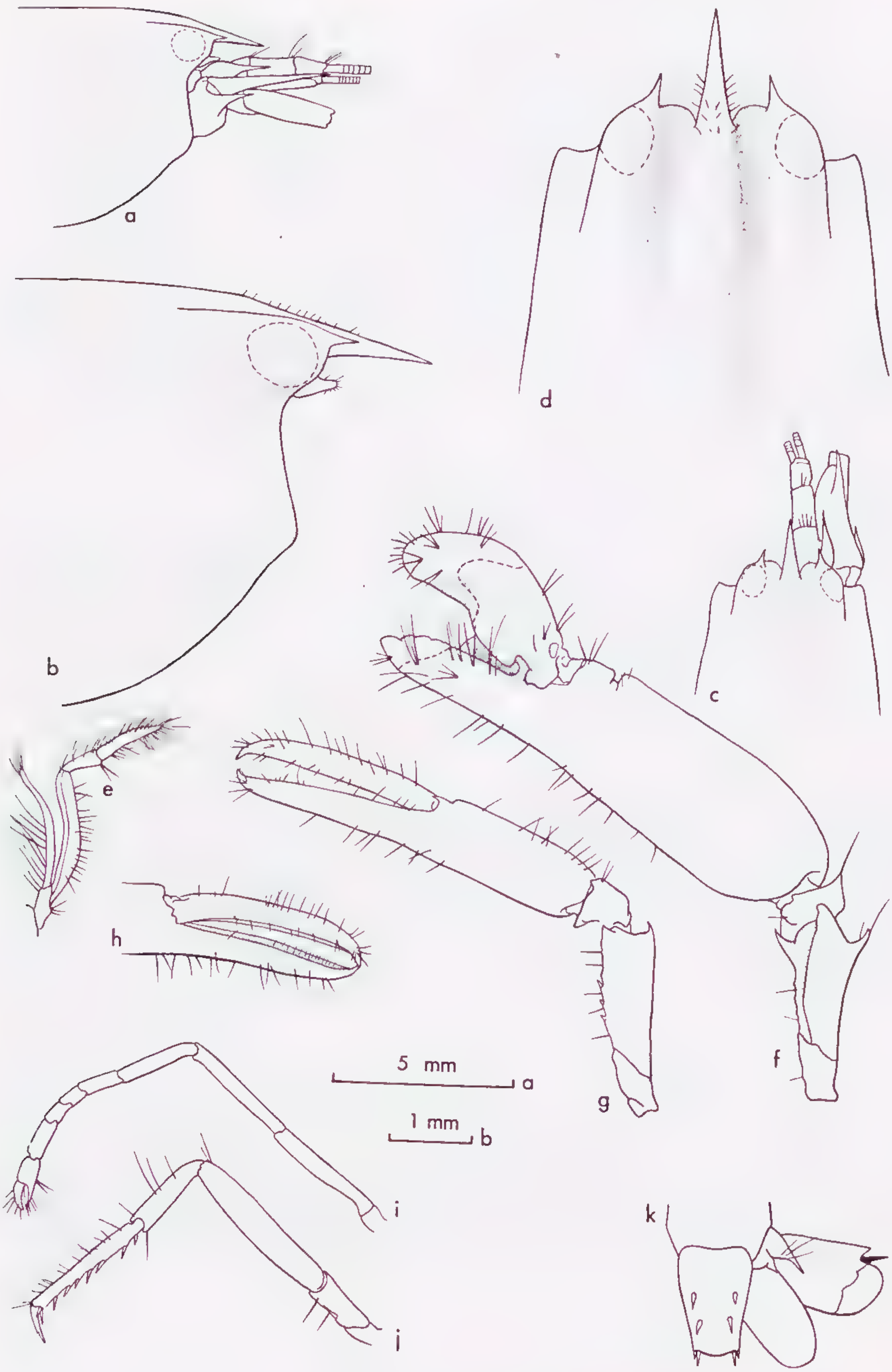

Fig. 1 *Alpheus brucei* sp. nov.

Holotype. a,b. Anterior region, lateral view; c, d. anterior region, dorsal view; e. third maxilliped, lateral face; f. large cheliped, lateral face; g. small cheliped, medial face; h. distal end of small chela, lateral face; i. second leg; j. third leg; k. telson and uropods. a, c, e, f, g, h, i, j, k scale a; b, d scale b.

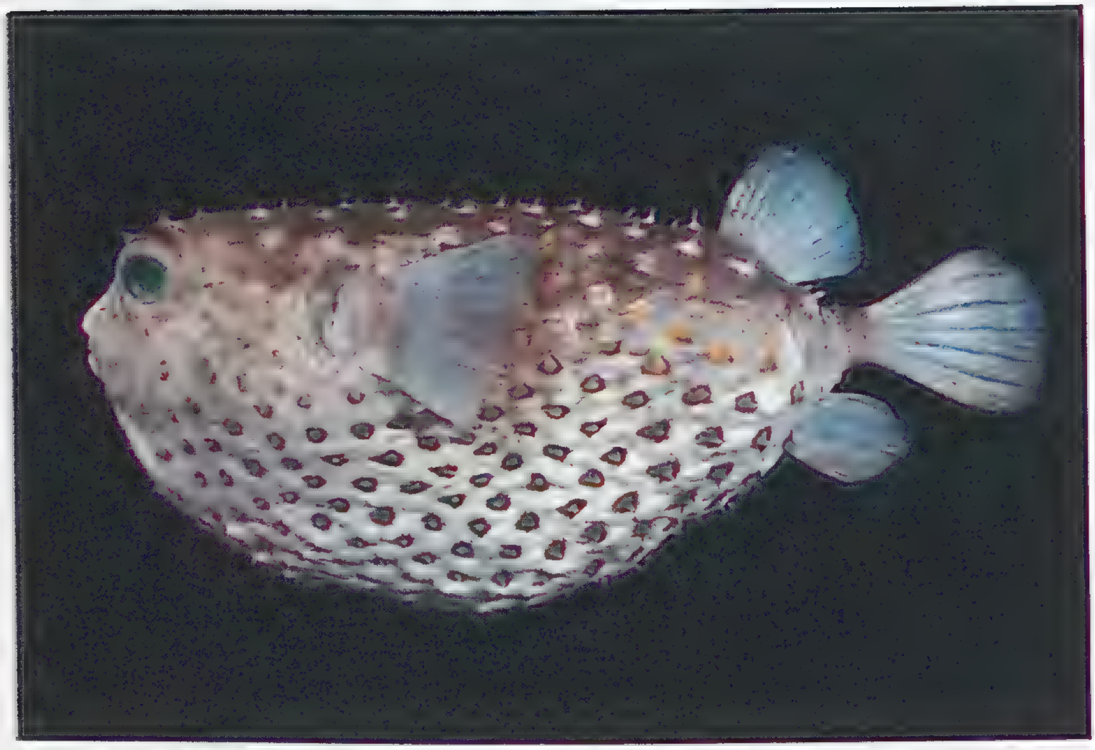

Figure 1. *Chilomycterus spilostylus*, holotype, 234mm SL, BPBM 13896, Gulf of Aqaba (J. Randall).

Figure 2. Underwater photo of *Chilomycterus spilostylus*, Gulf of Aqaba, Red Sea (J. Randall).

CHILOMYCTERUS SPILOSTYLUS, A NEW SPECIES OF INDO-PACIFIC BURRFISH (PISCES, TETRAODONTIFORMES, DIODONTIDAE)

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SUMMARY

A new spiny puffer (Diodontidae) *Chilomycterus spilostylus*, is described from ten specimens, from the northern Red Sea, the South China Sea and the Philippine Islands. *C. spilostylus* is distinguished from all other Indo-Pacific *Chilomycterus* by colour, spine morphology, and spine arrangement. All spines are fixed and short, and many on the head have four rather than three subdermal bases. A single medial frontal spine is located between the nostrils and three spines are over the eye. We tentatively conclude that the form incorrectly called *Cyclichthys echinatus* (Gronow) is the pelagic juvenile stage of *C. spilostylus*.

INTRODUCTION

The fishes of the tetraodontiform family Diodontidae have long attracted the attention of ichthyologists because of their unusual appearance and ability to inflate. This attention has resulted in a large number of synonyms in this relatively small family. For example, only five of the 28 nominal species of *Diodon* are valid (Leis 1978). A similar situation exists among the other diodontid genera which include approximately 50 nominal species. Thus, it is surprising to discover a widely distributed species of *Chilomycterus* (sensu lato) which is undescribed. This species, described below as *Chilomycterus spilostylus*, has been ignored or confused with *C. orbicularis* (Bloch) or *Cyclichthys echinatus* (Linnaeus). It first came to our attention when it was collected by Randall in the Gulf of Aqaba, Red Sea. We describe this species here in order to make the name available in advance of revisionary studies of the family by Leis.

MATERIALS AND METHODS

Counts, measurements and definitions generally follow Leis (1978), but some require amplification. The interpectoral spines (P-D-P spines) make up the transverse row over the dorsum between the upper bases of the pectoral fins. The spine arrangement on the top of the head gives the number of spines in the successive transverse spine rows from the frontal spine through the row at the level of the gill opening. This count excludes the supraorbital spines and other spines in an approximate longitudinal row with these (i.e. spines along the dorsolateral edge of the head). The second and third transverse rows are often irregular, and each could be interpreted as constituting more than one row. However, rows with an odd number of spines have the middle spine approximately on the dorsal midline, and those with an even number should have equal numbers on each side of the midline. The frontal spines constitute the anterior-most spine row on the top of the head (again excluding the supraorbital spines). Preserved specimens of diodontids are often distended due

Records of the Australian Museum, 1981, **Volume 34 Number 3**, 363-371, Figures 1-4.

to inflation or from being forced into small containers, resulting in a wide range in body proportions. This distortion is particularly evident in the snout to anus length. Therefore, morphometrics are of limited usefulness and must be interpreted with caution.

The caudal peduncle is measured from the posterior base of the dorsal fin. Head width is measured immediately behind the eyes, body width is measured at the pectoral fin base. Interorbital width is the least bony width along the anterior edge of the orbit. The distance from nostril to mouth is measured from the base of the nasal tentacle to the end of the gape. The last two dorsal and anal fin rays are counted separately because they have separate bases. Pectoral fin ray counts exclude the rudimentary uppermost nubbin-like ray. Measurements were made to the nearest 0.5 mm, and are given in millimetres unless stated. Abbreviations of institutions containing material examined are: AMS, Australian Museum, Sydney; BM (NH), British Museum (Natural History), London; BPBM, Bernice P. Bishop Museum, Honolulu; HUJF, Zoological Museum, Hebrew University of Jerusalem; USNM, United States National Museum of Natural History, Washington, D.C.; SU, Stanford University, which collections are housed at the California Academy of Sciences (CAS), San Francisco; MNHN, Muséum National D'Histoire Naturelle, Paris.

Chilomyterus spilostylus, new species
Figures 1-4

Chilomycterus echinatus? (non Linnaeus or Gronow):— Clark and Gohar, 1953:65 (Suez area, Red Sea).

Chilomycterus (Cyclichthys) echinatus (non Linnaeus or Gronow): — Chu, 1962:1105 (South China Sea).

Chilomycterus orbicularis (non Bloch): — Halstead, 1967: 857, plate 6 (Gulf of Aqaba, Red Sea).

Cyclichthys echinatus (non Linnaeus or Gronow): — Cohen, 1975:132, upper figure (Gulf of Aqaba).

Chilomycterus sp. — Darom, 1976: 86, Figure on p.87 (Gulf of Aqaba); Fridman and Levy, 1977: Figure 71 (Gulf of Aqaba).

HOLOTYPE: BPBM 13896, 234 SL, off Elat marine lab, Gulf of Aqaba, Red Sea, 12 m, J. E. Randall, 8 June 1972.

PARATYPES: AMS I. 20145-001, 187 SL, off Taba, Gulf of Aqaba, 3 m, reef, O. Gon and J. E. Randall, 9 August 1976. BM(NH) 1979.9.24.1, 261 SL, El Himeira, Gulf of Aqaba, 10 m, O. Gon, A. Barnes and A. Diamont, 2 Nov. 1975. BPBM 20456, 281 SL, Elat, Gulf of Aqaba, 10 m, patch reef and sea grass, J. E. Randall, 30 August 1977. BPBM 22724, 210 SL Magellan Bay, north side of Mactan Island, Cebu, Philippines, 30 m, silty sand bottom, J. E. Randall, 2 August 1978. HUJF 8343, 147 SL, Elat, Gulf of Aqaba, R. Lotam, 14 July 1965. SU68649, 145 SL, off Taya Islands, South China Sea (19°38'N, 111°30'E), 92 m (50fm), R. L. Bolin, 21 July 1958. USNM 216146, 270 SL, El Himeira, Gulf of Aqaba, 9-12 m, V.G. Springer, *et al.*, 8 September 1969. USNM 191665, 219 SL, Red Sea, E. Clark (1960).

DIAGNOSIS: A species of *Chilomycterus (sensu lato)* with all body spines fixed and relatively short. Spines all of approximately the same length. Spines triangular in cross section near the base, becoming rounded near the tip. Spines on the top of the head with three or four subdermal bases; other spines with three bases. Three spines

over the eye. The single, medial frontal spine located between the nostrils and in advance of all spines except the anterior suborbital spine. No spines wholly on the caudal peduncle. Nasal organ in the form of a hollow tentacle with two openings. No tentacles in adult other than the nasal ones. The teeth thickened and heavy. Fins without spots. Ground colour brown to grey dorsally fading to white ventrally. Spine bases with white spots dorsally, yellow spots laterally and black spots with yellow centres ventrally. No large blotches or bars.

DESCRIPTION: Measurements and counts in Table 1. Fin rays, Dorsal 12-13, Anal 10-12, Pectoral 20-22 (often asymmetrical), Caudal i, 7-8, i. Spines short and straight, none noticeably elongate; all spine shafts much shorter than their shortest subdermal base; spines triangular in cross section near the base, becoming round to somewhat laterally compressed near the tips (Fig. 3). All spines fixed in an upright position; those on the top of the head with three or (usually) four subdermal bases (the frontal spine with three bases), those elsewhere with three bases. Spine rows often irregular and difficult to count, but approximately 12 (in the longitudinal row including the frontal spine) anterior to the dorsal fin; approximately 19 from the lower jaw to the anus; approximately six interpectoral spines. Arrangement of spines on top of the head (5 transverse rows, Fig. 4) 1, 2, 3-5, 4-5, 4-5. The single medial frontal spine located between the nostrils and in advance of all spines but the anterior suborbital spines (which may be even with the frontal spine). Three supraorbital and two to four suborbital spines. No spines wholly on the caudal peduncle, although the inner subdermal base of the posterior spines surrounding the dorsal fin extends onto the peduncle. The subdermal bases of four (occasionally three) spines form the anterior edge of the depression surrounding gill opening. The body is capable of great inflation.

Dorsal, anal and caudal fins rounded, middle rays longest; pectoral fin slightly emarginate with upper and lower rays longer than middle rays. Dorsal and anal fins of approximately the same size and shape.

Nasal organ a hollow tentacle with two opposed openings near the tip. Nasal tentacles located in the interorbit at the level of the frontal spine.

Dental plates thick and strong.

No tentacles or barbels in adult other than the nasal organs.

Dorsal ground colour medium grey to dark brown fading gradually to a dirty white ventrum (Figs. 1, 2). Dorsally, to the level of the middle of the pectoral base, the base of each spine is covered by a small (less than pupil) light-coloured spot (often faded in preserved material). The ventral spine bases each have a similar black spot. In life the lateral, ventral and some of the dorsal spines (including the central portion of the spine base) are yellow. The fins are light to medium grey, but are never spotted. There is often a narrow white margin on the fins. The iris has a yellow ring in life. No bars or blotches in preserved material. The lower jaw is sometimes dusky (see colour plate VI in Halstead 1967).

DISTRIBUTION: *Chilomycterus spilostylus* is known from the northern Red Sea, the southern Arabian Peninsula, off Hong Kong and the Philippines. A wider distribution along the southern edge of Asia and perhaps the east African coast and Indo-Australian archipelago should be expected.

NAME: This name is a latinized noun in apposition formed by the Greek words 'spilos' (spot) and 'stylos' (pillar or post) referring to the contrasting spot at the base of

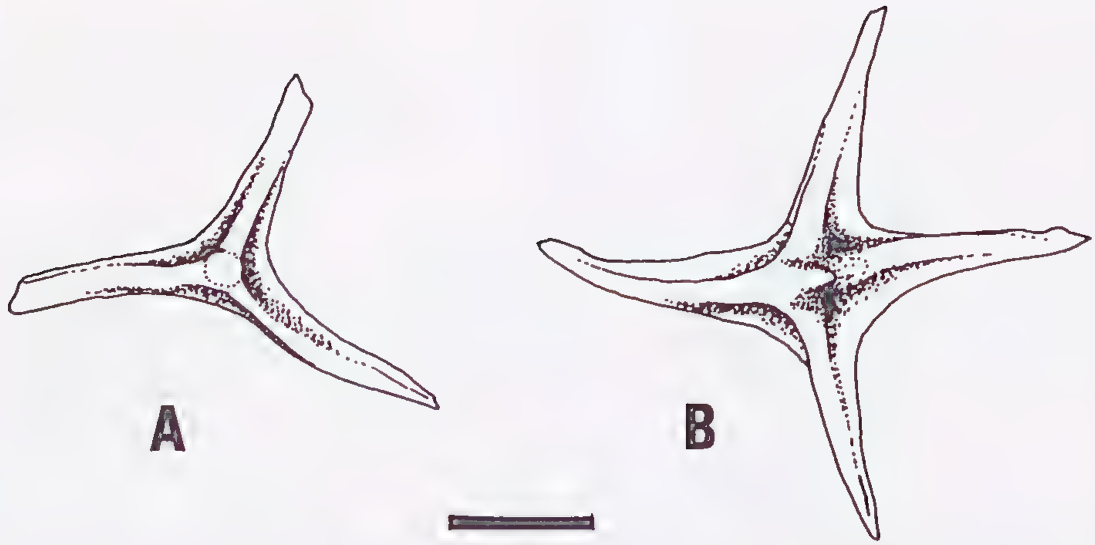

Fig. 3 Spine types of *Chilomycterus spilostylus*. A. Top view of a three-base spine of the right flank. B. Top view of a four-base spine of the top of the head. Both spines dissected from AMS I.20145-001. Scale bar equals 1 cm.

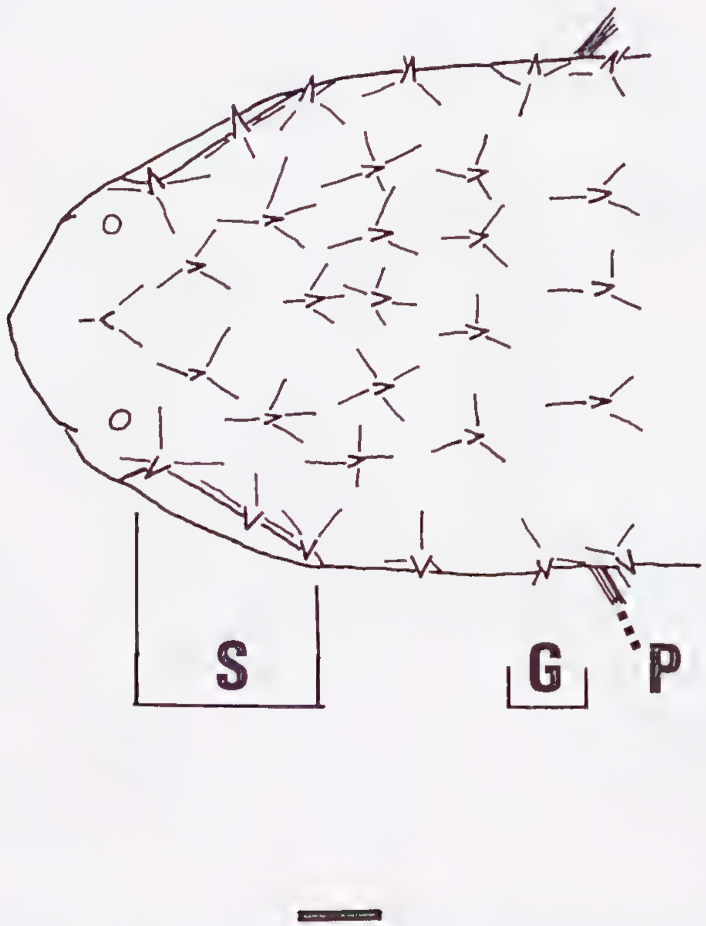

Fig. 4. Semi-diagrammatic dorsal view of the head of *Chilomycterus spilostylus* (AMS I.20145-001) to show arrangement of spines and their subdermal bases. Small circles represent the nasal organs. (S) supraorbital spines, (G) gill opening, and (P) pectoral fin. Scale bar equals 1 cm.

each spine. We propose the English common name of spot-base burrfish for *C. spilostylus* in reference to these spots.

ECOLOGY: *Chilomycterus spilostylus* is found in a variety of habitats. The specimen available to us have come from coral reefs, a sea grass bed, silty sand habitat and a wreck; one was trawled (the only specimen not captured by hand or speared). Capture depths ranged from 3 to over 90 m. The species appears to be solitary, although the trawled specimen was taken with seven *Chilomycterus orbicularis*. This species is probably nocturnal. When observed during daylight hours on the reefs in the Gulf of Aqaba it is inactive, usually beneath ledges or in small caves.

REMARKS: Present concepts of generic relationships within the Diodontidae require revision. The classification (three genera and eight subgenera) proposed by Fraser-Brunner (1943) is untenable, being based in part on ontogenetically varying characters and apparent confusion of type species. The common practice of recognizing only two genera, *Diodon* and *Chilomycterus,* is also invalid. Pending completion of revisionary studies by Leis, we choose the conservative option of allocating *spilostylus* to *Chilomycterus.*

The form incorrectly called *Cyclichthys echinatus* (Gronow) by Smith (1949) and others is almost certainly the pelagic juvenile stage of *C. spilostylus*. The available specimens of *C. echinatus* are generally smaller (129-155 mm) than those of *C. spilostylus* (145-281 mm), but the habitat of *C. echinatus* is unknown because all available specimens were found on South African beaches. However, pelagic warm water fishes are often found on South African beaches, presumably because they become moribund in the cold Southern Ocean after moving south in the warm Mozambique and Agulhas currents (Smith, 1949). Aside from size, *C. echinatus* and *C. spilostylus* differ only in colour, length of fins and in the presence of fleshy tentacles in *C. echinatus* (actually, some specimens lack the tentacles, but they may have been eroded on the beach). The differences in colour and fin length are expected for the pelagic dispersive stage common in the family (Leis, 1978), but the tentacles are not. The tentacles and lack of overlap in the known distributional range of the two forms introduce some doubt as to their conspecificity. Because of this doubt, we do not formally synonymize the two forms and do not include any material of the "echinatus" form in the type series of *C. spilostylus*. The nominal species *Diodon echinatus* Linnaeus is a synonym of either *Diodon hystrix* Linnaeus or *Chilomycterus reticulatus* (Linnaeus). Günther (1870) incorrectly called the South African form *Chilomycterus echinatus* (Gronow), and Smith (1949) called the tentacled form *Cyclichthys echinatus* (Gronow). This will be fully discussed by Leis (in prep.). Because the name *echinatus* is not available for the tentacled form, and no other name has been applied to it, a new name will be required if it proves distinct from *C. spilostylus*. We avoid naming it because we feel it will prove to be conspecific with *C. spilostylus,* and take the course of nomenclatorial conservativism by referring to the tentacled form as *C. spilostylus* (?). Assuming the two forms are conspecific, no other species is obviously closely related to *C. spilostylus*.

Chilomycterus spilostylus has occasionally been misidentified as *Chilomycterus orbicularis* of authors. *C. orbicularis* is readily distinguished by the relatively thin, weak dental plates, a possibly erectile and somewhat elongate spine in the pectoral axil, the longer, slightly recurved spines, and the colour pattern which lacks small spots associated with the spine bases.

The other species of *Chilomycterus (sensu lato)* occurring within the known range of *C. spilostylus* can be distinguished from it by one or more of the following

characteristics (all lacking in *C. spilostylus*): erectile spines, on head, ventrum or pectoral axil; colour pattern which lacks small spots associated with spine bases; a spine wholly on caudal peduncle; or nostrils not a hollow tentacle with two openings.

After this paper was submitted, two specimens of *C. spilostylus* were received, one from Suez (MNHN 1966-223) and one from Muscat,Oman (BM(NH) 1889-4-15:76). These specimens are not included in the type series, and do not significantly differ from it in any character except the Muscat specimen has 11 dorsal fin rays.

ACKNOWLEDGEMENTS

Field work by Randall was supported by grant no. 439 from the U.S.-Israel Binational Science Foundation, and was assisted by many associates (see collection data). Leis was supported by an Australian Queen's Fellowship in Marine Science. The following people aided our investigation by providing information or loaning specimens: P. Sonoda (CAS), W. N. Eschmeyer (CAS), A. Ben-Tuvia (HUJF), V. G. Springer (USNM), S. Karnella (USMN), B. B. Collette (U.S. National Marine Fisheries Services Systematics Laboratory, Washington, D.C.), M. L. Bauchot (MNHN) and A. C. Wheeler (BM(NH)). A grant to Randall from the Engelhard Foundation provided funds for the colour plate. D. F. Hoese (AMS) read and criticised the manuscript. H. K. Larson (AMS) drew Fig. 3. Our sincere thanks to all.

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NOTE ADDED IN PROOF

While this paper was in proof, information extending the known range of *C. spilostylus* became available. A 167 mm specimen from off Bombay was examined through the courtesy of E. Silas of the Central Marine Fisheries Research Institute, Cochin, India (Cat. No. CMFRI-F. 116/489), and a photo of a specimen from Bali, Indonesia was provided by P. J. P. Whitehead (BMNH). This fulfills the expectation (above) of a wider distribution in Southern Asia and the Indo-Australian Archipelago. To date, no material unquestionably conspecific with *C. spilostylus* has been seen from the Indian Ocean coast of Africa, although the species may be expected to occur there.

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TABLE 1. Counts and measurements (in millimetres) for type specimens of *Chilomycterus spilostylus* (percent standard length given in parentheses).

	Holotype	Paratypes			
	BPBM 13896	SU 68649	HUJF 8343	AMSI. 20145-001	BPBM 22724
Standard Length	234	145	147	187	210
Dorsal Rays	13	12	13	13	12
Anal Rays	11	11	11	12	11
Pectoral Rays	21,22	21,21	22,22	22,22	21,22
Caudal Rays	i,7,i	i,7,i	i,7,i	i,7,i	i,7,i
Head Length	86(36.8)	51(35.2)	55(37.4)	71(38.0)	85.5(40.7)
Snout to Anus Length	203(86.8)	131(90.3)	115(78.2)	150(80.2)	179(85.5)
Pre-dorsal Length	185(79.1)	115(79.3)	118(80.3)	148(79.1)	164.5(78.5)
Peduncle Length	29.5(12.6)	23(15.9)	18(12.2)	22(11.8)	26.5(12.6)
Least Peduncle Depth	16.5(7.1)	10.5(7.2)	10.5(7.1)	10(5.3)	14.5(6.9)
Eye Width	21(9.0)	15(10.3)	18(12.2)	16(8.6)	18(8.6)
Head Width	72(30.8)	51(35.2)	58(39.5)	60(32.1)	73(34.8)
Body Width	75(32.1)	51(35.2)	65(37.4)	73(39.0)	70(33.4)
Interorbital Width	47(20.1)	29(19.9)	31(21.1)	36(19.3)	42(20.0)
Nostril to Mouth Length	21(9.0)	15(10.3)	17(11.6)	18(9.6)	22(10.5)
Height of Gill Opening	23(9.8)	13(9.0)	16.5(11.2)	18.5(9.9)	19.5(9.3)
Mouth Width	33(14.1)	20.5(14.1)	23(15.6)	24(12.8)	26.5(12.6)
Longest Dorsal Ray	45(19.2)	27(18.6)	33(22.4)	32.5(17.4)	40(19.0)
Longest Pectoral Ray	45(19.2)	27(18.6)	29.5(20.1)	32.5(17.4)	38.5(18.3)
Longest Caudal Ray	62(26.5)	36.5(25.2)	42.5(28.9)	40.5(21.7)	56(26.6)
Head Spination	1,2,5,5,5	1,2,3,4,4	1,3,4,5,4	1,2,3,5,4	1,2,4,4,4
Pre-dorsal Spines	14	11	12	12	12
Preanal Spines	20	16	18	18	17
Interpectoral Spines	6-7	6	6	5-7	6
Length of Longest Dorsal Spine	8	7.5	5	7.5	7
Length of the Frontal Spine	5.5	5	5	7	6
Length of Longest Ventral Spine	9	6	6	6.5	7

Table 1 Continued

	Paratypes					
	USNM 191665	BPBM 21174	BM(NH) 1979.9.24.1	USNM 216146	BPBM 20456	Mean
Standard Length	219	225	261	270	281	—
Dorsal Rays	12	12	12	12	12	12.3
Anal Rays	12	10	11	12	12	11.3
Pectoral Rays	21,21	21,21	20,20	21,21	21,22	21.3
Caudal Rays	i,7,i	i,8,i	i,7,i	i,7,i	i,7,i	i,7.1,i
Head Length	85(38.9)	73(32.4)	91(35.0)	100(37.0)	93(33.1)	(36.5)
Snout to Anus Length	178(81.3)	185(82.2)	205(78.8)	210(77.8)	227(80.8)	(82.2)
Pre-dorsal Length	172(78.5)	177(78.7)	210(80.8)	211(78.1)	230.5(82.0)	(79.4)
Peduncle Length	28(12.8)	28(12.4)	30(11.5)	30(11.1)	33(11.7)	(12.5)
Least Peduncle Depth	15(6.8)	17(7.5)	18(6.9)	18(6.7)	17(6.1)	(6.8)
Eye Width	21(9.6)	22.5(10.0)	23(8.8)	24(8.9)	23.5(8.4)	(9.4)
Head Width	75(34.2)	73.5(32.7)	85(32.7)	87(32.2)	86.5(30.8)	(33.5)
Body Width	83(37.9)	75(33.3)	101(38.5)	104(38.5)	94.5(33.6)	(35.9)
Interorbital Width	42.5(19.4)	45(20.0)	50(19.2)	56(20.7)	60(21.4)	(20.1)
Nostril to Mouth Length	21(9.6)	26(11.6)	26(10.0)	27(10.0)	27(9.6)	(10.2)
Height of Gill Opening	17(7.8)	22.5(10.0)	26(10.0)	27.5(10.2)	24(8.5)	(9.6)
Mouth Width	31(14.2)	35.5(15.8)	37(14.2)	28(10.4)	28.5(13.7)	(13.7)
Longest Dorsal Ray	41(18.7)	43(19.1)	49(18.8)	51(18.9)	53(18.9)	(19.1)
Longest Pectoral Ray	42(19.2)	42(18.7)	49.5(19.0)	51(18.9)	54(19.2)	(18.9)
Longest Caudal Ray	47(21.5)	57.5(25.6)	67.5(25.9)	68(25.2)	67.5(24.0)	(25.1)
Head Spination	1,2,4,4,4	1,2,3,5,4	1,2,3,5,4	1,2,3,5,4	1,2,4,4,4	
Pre-dorsal Spines	13	13	13	12	12	
Preanal Spines	21	20	20	20	18	
Interpectoral Spines	6	6	5-6	6	6	
Length of Longest Dorsal Spine	9	8	9	7.5	9	
Length of Frontal Spine	6.5	5.5	6	7	6.5	
Length of Longest Ventral Spine	7	7	8	7	9	

DESIGNATION OF A NEOTYPE OF *CAPITELLA FILIFORMIS* CLAPARÈDE, 1864, TYPE SPECIES OF THE GENUS *HETEROMASTUS* (POLYCHAETA: CAPITELLIDAE)

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SUMMARY

The synonymy of *Heteromastus filiformis* (Claparède, 1864) was examined to clarify the status of the genus *Heteromastus* Eisig, 1887. The synonymy is confused by inadequate descriptions and the absence of type material of *Capitella filiformis* Claparède, 1864, or of any of its synonyms. A neotype of *C. filiformis* Claparède was designated to stabilize the future use of *Heteromastus* Eisig.

INTRODUCTION

Heteromastus filiformis (Claparède, 1864) is a cosmopolitan species, occurring in a wide variety of habitats, and is commonly referred to in the ecological literature.

This species is also recognized by most workers as the type species of the genus *Heteromastus* Eisig, 1887. From Eisig's description, it is apparent that some confusion exists in the diagnostic characters of the genus *Heteromastus* as defined by the type species. Most subsequent workers have ignored this confusion, but we feel it is essential to redescribe the type species of *Heteromastus, H. filiformis,* to stabilize this common and widely distributed genus, and also to stabilize the genus *Mediomastus* Hartman, 1944.

The following abbreviations have been used below: AM W — Australian Museum; HMV — Zoologisches Institut, Hamburg; USFC — United States Fisheries Commission; USNM — United States National Museum, Smithsonian Institution; YPM — Peabody Museum of Natural History, Yale; MNHN — Museum National D'Histoire Naturelle, Paris.

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TAXONOMY

Heteromastus Eisig, 1887

DIAGNOSIS: Thorax with 12 segments first asetigerous, setigers 2-6 with capillary setae and setigers 7-12 with hooded hooks, abdominal setae all hooded hooks. Notopodial branchiae present on posterior abdomen.

TYPE SPECIES: *Capitella filiformis* Claparède, 1864.

Heteromastus filiformis (Claparède, 1864)

Capitella filiformis Claparède, 1864: 49-50, Pl. IV, fig. 10. — Eisig, 1887: 839, 841-843. Type-locality: Port-Vendres; France.

Notomastus filiformis Verrill, 1873a: 611. — 1882: 302. — Webster, 1879a:123, Pl. 5, figs 51-54. — 1886: 152-153, Pl. (V) VIII, figs 51-54. — Webster and Benedict, 1884: 730. — Eisig, 1887: 870. — Hartman, 1942: 70 [*partim*]. — 1947: 427. Type locality: Great Egg Harbour, New Haven, Watch Hill, Vineyard Sound; U.S.A.

Notomastus luridus. — Verrill, 1874: 370. — Eisig, 1887: 869 [*partim*]. [*Non* Verrill, 1873a: 610.]

[?] *Areniella filiformis* Verrill, 1874: 386-387. — Hartman, 1942: 70. — 1944: 334, 341. — 1947: 427. Type locality: Casco Bay; U.S.A.

Ancistria minima. — Webster, 1879a, 1879b: 122, 258. [*fide* Hartman, 1947: 427.]. [*Non* Quatrefages, 1865: 252-253, Pl. 11, figs. 28-34.]

Notomastus laevis Webster, 1886: 152. [*fide* Hartman, 1947: 427.] Type locality: Provincetown; U.S.A.

Heteromastus filiformis Eisig, 1887: 839-840. — Fauvel, 1927: 150-152, fig. 53 a-i. — Hartman, 1947: 427-428, Pl. 52, figs 1-4. — Uschakov, 1965: 304 [*partim*]. — Day, 1967: 601, fig. 28-3a-d. — Hartmann-Schröder, 1971: 400-403 [*partim*]. — Hutchings and Rainer 1979.

MATERIAL EXAMINED: *Capitella filiformis* Neotype MNHN AS405, Alexandria, Egypt, 1933, ident. P. Fauvel. *Notomastus filiformis* YPM 1444 (1 spec.), Watch Hill, R.I., low water, Apr. 1873, ident. A. E. Verrill; YPM 1446 (1 spec.), Vineyard Sound, Mass., 1871, USFC 43, ident. A. E. Verrill; YPM 1460 (1 spec.), Great Egg Harbour, N. J., ident. A. E. Verrill; USNM 12188 (1 spec.), Gutters, Woods Hole, Mass., Aug. 1881, ident. A. E. Verrill; USNM 12189 (8 specs.); 12191 (20 specs.); 12193 (4 specs.), 2 fm, Newport, R.I., 2 Aug. 1880, ident. A. E. Verrill; USNM 16128, Hog Island, Casco Bay, Maine, low water, USFC, 1873, ident. A. E. Verrill. *Areniella filiformis* USNM 16129 (2 specs.), Cape Cod, 15 fm, 29 Aug. 1879, USFC St. 313, ident. A. E. Verrill. *Notomastus luridus* USNM 16128 (3 specs.), Hog Island, Casco Bay, Maine, low water, USFC, ident. A. E. Verrill. *Heteromastus filiformis* USNM 32151 (15+ specs.), Barnstable Flats, Mass., 23 Aug. 1954, coll. & ident. M. Pettibone; USNM 32149 (15+ specs.), West Falmouth Harbour, Mass., 11 July 1954, coll. & ident. M. Pettibone; USNM 32147 (7 specs.), Wallfleet Harbour, Mass., 29 Aug. 1954, coll. & ident. M. Pettibone; HMV-12317, North Sea (Sylt), coll. R. Wescherrfelder, ident. H. Augener.

Australian material (representative samples of the material examined):
Victoria: Port Phillip Bay Environmental Survey, 1969-1973. AM W5647, Stn. 966, 23 Jan. 1973; AM W16190, Stn.939, 18 Feb. 1971; AM W16334, Stn. 1224, 9 Mar. 1971; AM W16622, Stn. 966, 23 Jan. 1973; AM W16626, Stn. 984, 17 Feb. 1971. Westernport

Environmental Survey, Nov. 1973-Jan. 1974; AM W16861, Stn. 1717, 1 Jan. 1974; AM W16862, Stn. 1717-2, 2 Jan. 1974.
NSW: Merimbula Lake. — *Posidonia,* AM W11269, 11356, 12737, Oct. 1975; *Zostera,* AM W11917, Dec. 1975. Port Hacking. — *Posidonia,* AM W9591, May 1975; AM W11014, Nov. 1975; AM W11164, Aug. 1976. Botany Bay, Towra Point. — sand, AM W7739; *Posidonia,* AM W9637, 9689, 9705, 9725, 9735, 9759, Apr. 1973. Malabar. — AM W6509, 51 m, 16 May 1972. Careel Bay. — *Posidonia,* AM W8357-60, Dec. 1973.
Queensland: Gladstone. — Auckland Ck., AM W13239; Calliope R., AM W13525-6, 13528, May 1976.

DESCRIPTION: Neotype, 52 mm long, 0.6 mm wide at thorax, 0.4 mm wide at posterior abdomen, with approximately 160 segments, incomplete posteriorly. Colour of alcohol-preserved specimen, light brown in anterior and posterior segments, colourless in middle segments. Prostomium small, conical, without eyespots. Thorax of 12 segments, first segment asetigerous. Thorax, smooth and slightly inflated anteriorly, areolated and narrowed posteriorly; anterior abdominal segments project posterodorsally, demarcation between thorax and abdomen distinct. Nephridiopores not visible in thorax. Setae of segments 2-6, narrow, limbate capillaries; setae of segments 7-12, hooded hooks; setae of all abdominal segments, hooded hooks; tori of all segments short. Dental formula of abdominal hooks, main fang: 3-4:4-5:4-6. Thoracic setae, 12-18 capillaries per ramus in segments 2-6, 10-14 hooded hooks in segments 7-12. Abdominal setae, notopodia with 8-9 hooded hooks per torus in anterior segments, decreasing to 1-2 per torus in segments with gills; neuropodia with 12-14 hooded hooks per torus in anterior segments, decreasing to 3-5 per torus in posterior segments. Gills, short, broadly-based, rounded lamellae projecting posteriorly over adjacent segment, commencing from about segment 100, well-developed by segment 120.

COMMENTS: We have examined material from the Mediterranean, the North Sea, Australia and the east coast of the USA, from a range of soft-bottom habitats. The material varies considerably in size and in the extent to which gills are developed. We could not detect any consistent differences between material from different localities, and agree with the widely-held understanding that *Heteromastus filiformis* is a cosmopolitan species.

Capitella filiformis was described from Port-Vendres, France, while Eisig (1887) worked on material from the Gulf of Genoa, Italy. The neotype was selected from the only Mediterranean material available to us. It lacks posterior segments, and appears to have been stretched during preservation.

Complete specimens, from the east coast of the U.S.A., have up to 230 setigers for a length of 40 mm, and the abdomen terminates in a small digitiform caudal cirrus. The anterior thorax is usually inflated, and the demarcation between thorax and abdomen is usually distinct. Nephridiopores are present between segments 7-8, 8-9, 10-11 and 11-12; in some specimens there appears to be a nephridiopore between segments 6-7. Gills are variably developed on the abdomen, and appear to be absent in small specimens. In large specimens, gills are usually first present by segment 80, and are well-developed by segment 100. The substantially reduced number of setae in posterior abdominal segments seems to be a constant feature.

Among the material we examined from the east coast of the U.S.A. were specimens variously identified by Verrill as *Notomastus filiformis, Notomastus luridus* and *Areniella filiformis*. Some of this material had been examined by Hartman, who concluded in an initial paper (1942) that both *N. filiformis* Verrill, 1873 and *A. filiformis*

Verrill, 1874 were indeterminable. In a later paper (Hartman, 1947), however, these species were accepted as synonyms of *H. filiformis*. We have re-examined this material and it does contain some specimens of *H. filiformis* and we consider that *A. filiformis* is synonymous with *H. filiformis*. The specimens of *N. filiformis* that we examined, from the type locality for the species, were in excellent condition, and agreed with the accepted description of *Heteromastus filiformis*. The specimens of *A. filiformis* that we examined, collected from Cape Cod in 1879, also agreed well with *H. filiformis*. The specimens of *N. luridus* that we examined, from Casco Bay, also agreed with the description of *H. filiformis*. These were not type specimens, and we do not disagree with Hartman's conclusion that *N. luridus* is a valid species of *Notomastus*. We did not examine the type material of *N. luridus* (YPM 24-14) selected by Hartman (1942).

DISCUSSION

A fixed number of thoracic segments and a constant setal pattern are considered to be generic characters in the family Capitellidae. New species often have not conformed to the diagnoses of existing genera, and the result has been a proliferation of genera within the family. The precise affinities of genera are often unclear, and the family is in need of careful revision, which is beyond the scope of this study. Before this revisionary study can be undertaken, material of the type species of *Heteromastus* Eisig must be examined. No type material exists and, as discussed below, the synonymy is confused. We have therefore designated a neotype of *Capitella filiformis* Claparède, 1864. This neotype agrees with the original diagnosis of *Heteromastus*, by Eisig (1887) given above, which has been widely accepted by polychaete specialists such as Fauvel (1927), Hartman (1947), Hartmann-Schröder (1962), Day (1967) and Fauchald (1977). However, some workers have not accepted this diagnosis. For example, Uschakov (1965) defined the genus as having 12 thoracic segments, with capillary setae on a variable number (4-6) of thoracic segments. Such an interpretation may be the result of Eisig's (1887) description of the type species of *Heteromastus, H. filiformis* (Claparède, 1864) in which juveniles of *Heteromastus* may have a reduced number of thoracic segments. The latter interpretation of the genus is implicit in the studies of Wesenberg-Lund (1941), Rasmussen (1956) and Hartmann-Schröder (1971). The reference to *Heteromastus* McIntosh, 1885 by Hartmann-Schröder (1971) appears to be a *lapsus calami*.

In capitellids, the number of adult thoracic segments is constant and in most genera there is a clear demarcation between thorax and abdomen. Somatic growth in polychaetes, and certainly in capitellids, occurs by the proliferation of segments just anterior to the pygidium. The number of thoracic segments is fixed very early in development, and all segments developing subsequently are abdominal. There is evidence that the thoracic setal distribution in the genus *Capitella* may change during growth but there is no evidence of the total number of thoracic segments changing with increasing size (Warren, 1976). Our experience of examining many hundreds of specimens of *Heteromastus filiformis*, including many small individuals from Port Phillip Bay, Victoria (total length 1-2 cm), provides no evidence of changes in thoracic setal pattern or number of thoracic segments with increasing size of individuals. We believe that it is highly unlikely that juvenile animals of *Heteromastus* have a different number of thoracic setigers or setal pattern from adults. Similarly, none of the workers using Eisig's definition of the genus, Fauvel (1927), Hartman (1947), Hartmann-Schröder (1962), Day (1967) and Fauchald (1977), have indicated any variation in setal counts in small individuals. The variant interpretations by Wesenberg-Lund (1941), Rasmussen (1956) and Hartmann-Schröder (1971) were based

on material with only 11 thoracic segments. Subsequently, Rasmussen (1973) redescribed the *H. filiformis* of his 1956 paper as a new species, *Mediomastus fragilis*. Warren (1979) believed that *M. fragilis* has mistakenly been described by other workers as *H. filiformis*, and we consider it likely that the other authors were also referring to species of *Mediomastus*.

The genera of capitellids that had been erected by 1887 were usually poorly defined. Eisig (1887) endeavoured to clarify the situation on the basis of material available to him from the Gulf of Naples. The inadequacy of many species' descriptions was evident to Eisig as was the likelihood that many of the species were synonymous. According to the original diagnosis of *Heteromastus* by Eisig, the thorax comprised 12 segments, an achaetous segment followed by 5 setigers with capillary setae and then a further 6 setigers with hooded hooks. Eisig designated *Capitella filiformis* Claparède, 1864 as the type species of *Heteromastus*, and included the following species as synonyms of *C. filiformis: Capitella costana* Claparède, 1869; *Ancistria minima* Quatrefages, 1865; *Ancistria capillaris* Verrill, 1874; *Notomastus capillaris* Verrill, 1880; *Arenia* sp. ? Verrill, 1873. *Capitella fimbriata* Van Beneden, 1857 was doubtfully included in the synonymy. Eisig did not examine any material to establish the synonymy.

Claparède described *Capitella filiformis* from mature specimens, having the first 4 thoracic segments with capillary setae, the following 6 thoracic and all abdominal segments with hooded hooks. The characteristics of the setae include having the hooded hooks of the abdomen at least three times longer (0.078 mm) than those of the thorax (0.022 mm). This is at variance with Eisig's diagnosis of *Heteromastus*, apparently having one fewer thoracic segment with capillary setae. It is apparent from the many references in the systematic and ecological literature that a species conforming to the description of *Heteromastus filiformis sensu* Eisig is a common cosmopolitan species. Since there is a discrepancy between the description of *Capitella filiformis* and the diagnosis of the genus *Heteromastus* we attempted to examine Eisig's material and the type material of *C. filiformis* and its synonyms. We contacted all the major museums in Europe and many on the east coast of the United States of America. We were able to locate only some non-type material identified by Verrill as *Ancistria capillaris* Verrill, 1874. This material has previously been examined by Hartman (1942). All other type material, together with Eisig's material, is presumed lost or never deposited at all. It seems unlikely, for example, that Claparède ever deposited any material. In his 1869 paper he asks "Pour-quoi M. de Quatrefages, . . . s'est-il laissé entraîner à décrire tant de genres et d'espèces d'après des individus conservés dans l'alcool au Muséum de Paris? Il sait, mieux que personne, que ce genre de travail est profondément inutile, que les Annélides ne peuvent bien s'étudier qu'au bord de la mer, à l'aide d'individus vivants. Décrire, comme il le fait, tant de variétés *alcooliques*, c'est embarrasser la science d'un *càput mortuum* dont il faudra de longues années pour se débarrasser."

Since no type material of *Capitella filiformis* or any of its synonyms could be found, we then examined the descriptions of each species in detail to determine whether any of these was closer to *Heteromastus* Eisig than *C. filiformis* Claparède. These are considered below.

Capitella fimbriata Van Beneden, 1857: 140. Van Beneden's description does not allow the species to be distinguished from several capitellid genera. D'Udekem (1859) expanded Van Beneden's description, but did not quote the number of thoracic segments or give any indication as to where the setae commenced. No diagrams were given. Since the thoracic setal pattern is unclear, and the number of thoracic segments is unknown, we consider that *C. fimbriata* is indeterminable.

Ancistria minima Quatrefages, 1865. This species was described from an adult or sub-adult individual having an anterior region with simple (= capillary?) setae in both rami and a posterior region with hooded hooks in both rami. No diagrams were given. Since the number of thoracic segments is unknown, we consider that *A. minima* is indeterminable.

Capitella costana Claparède, 1869. This species was described as having the first two segments (buccal included) with fringed subulate setae and the nine following segments, with setae having a large terminal paddle (= hooded hook?). No diagrams were given. A thoracic setal formula of 11 setigers, of which only the first 2 have capillary setae, is strongly at variance with the adult diagnosis of *Heteromastus* Eisig and we consider that *C. costana* cannot be placed in the genus *Heteromastus* Eisig.

Ancistria capillaris Verrill, 1874. This species was described as having the first four segments with capillary setae, and succeeding segments with uncini. Subsequently Verrill (1880) renamed *A. capillaris* as *Notomastus capillaris,* without amplifying the original description. No diagrams were given. As the number of thoracic segments is unknown, we consider that *A. capillaris* Verrill and *N. capillaris* (Verrill) are indeterminable.

Arenia sp.? Verrill, 1873b. The name was used by Verrill in 1873, without a description. In 1882, Verrill synonymized *Arenia* sp.(?) with *Notomastus capillaris* Verrill, 1880. As argued above, *Arenia* sp.? is also indeterminable.

We did, however, find material of *Notomastus filiformis* Verrill, 1873, a species that Eisig 1887 had considered indeterminable, but that Hartman (1947) had synonymized with *H. filiformis.* We examined type material of *Notomastus filiformis* Verrill and found that it conformed to Eisig's definition of the genus *Heteromastus*. This represents the earliest published description with extant type material which conforms to *Heteromastus* Eisig. However, this species was not included in the synonymy established by Eisig for *H. filiformis* and thus is not available as a type species of the genus *Heteromastus.*

Of the synonyms given by Eisig for *Heteromastus filiformis,* the description of *Capitella filiformis* conforms most closely to Eisig's diagnosis. If *Capitella filiformis* is rejected as the type species of *Heteromastus* Eisig, then a new genus would have to be erected, possibly with *Notomastus filiformis* as its type species. We consider that the similarities between Claparède's description and Eisig's description of *H. filiformis* are such that the erection of a new genus is not required.

Two differences between Claparède's description and that of Eisig (1887) are in the number of anterior thoracic segments and the presence or absence of branchiae. All known species with 10 or more thoracic setigers normally have an achaetous peristomial segment. This suggests that Claparède either did not examine the anterior of his animals carefully or that he was dealing with specimens that had been damaged in some way and had not regrown their normal complement of anterior segments. In either case, it is likely that he was dealing with a species that possessed more thoracic segments than described. Branchiae in *Heteromastus filiformis* are not developed before about the 80th segment, and often not until about the 120th segment. They are initially small and could easily be missed when examining anterior fragments. Evidence suggesting that Claparède was dealing with *Heteromastus filiformis sensu* Eisig includes the number of thoracic segments with hooded hooks, the size and form of the hooded hooks, the absence of any copulatory apparatus and the relatively large size and number of segments in the mature individuals.

Heteromastus filiformis sensu Eisig has been widely referred to, and it is therefore desirable to maintain the stability and use of the genus *Heteromastus* and of the species *H. filiformis sensu* Eisig. The designation of a neotype of *Capitella filiformis* Claparéde permits such stability to be maintained. We recognize that the neotype does not agree in some respects with Claparède's description. However, it does conform to the description of Eisig, and to most subsequent descriptions, and we consider that these differences probably result from the use of incomplete and possibly atypical material as the basis of Claparède's description.

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A REVIEW OF PRESENT KNOWLEDGE OF THE FAMILY PELORIDIIDAE AND NEW GENERA AND NEW SPECIES FROM NEW ZEALAND AND NEW CALEDONIA (HEMIPTERA: INSECTA)

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CONTENTS

SUMMARY

The Peloridiidae, a family of small flattened cryptically coloured relict Hemiptera which for the most part live in saturated moss, form part of the "Antarctic" or Gondwanaland fauna, and are of uncertain relationships.

Up to the present 21 species have been described. Of these 6 species occur in southern South America, 6 in New Zealand, 6 in Australia and 3 on Lord Howe Island.

In the South American fauna, a new generic name, *Kuscheloides*, is proposed to replace *Kuschelia* China (preoccupied). Four new species are added to the new Zealand list. Two of these are assigned to a new genus, *Xenophysella*, type species *Xenophyes stewartensis* Woodward (*X. dugdalei* sp. n., *X. pegasusensis* sp. n.). Another belongs to *Xenophyes* Bergroth (*X. kinlochensis* sp. n.), while the fourth species, *Oiophysa pendergrasti* Woodward, previously had sub-specific rank. The first peloridiid to be recorded from New Caledonia is also described (*Oiophysella* gen. nov., type species *O, degenerata* sp. n.).

Illustrations and brief particulars are given of every known representative of the family Peloridiidae, also a summary of existing knowledge of the group. In addition, some aspects of the morphology of the head, and of the significance of paranota are discussed, likewise the position of the family within the order Hemiptera.

Records of The Australian Museum, 1981, Vol. 31 No. 5, 381-406, Figures 1-16

HISTORICAL

The history of the discovery of the several described species of the Peloridiidae and particulars of the environments they frequent, have been given by several authors. The most complete account is given by China (1942) who earlier, together with Helmsing, discussed their biology and ecology (Helmsing and China, 1937).

A gap of 27 years exists between the publication in 1897 of the description of the first species and that of the second, in 1924. The reason for this delay was lack of knowledge of their particular environmental requirements. Hacker (1932) was the first to establish the association existing between these insects and mosses, a discovery that led to the finding of several more species in subsequent years.

The availability of abundant material enabled attention to be paid to several of the unusual structural features of these insects. Thus the morphology of the head was described by Myers and China (1929), Evans (1938), and Sawai Singh (1971); of the thorax by Evans (1939) and of the abdomen, including the genitalia, by Myers and China (1929), China (1962) and Woodward (1956). The last-named also discussed the possible inter-relationships of the several species.

The internal anatomy was described first by Evans (1937) and subsequently, and in a more comprehensive fashion, by Pendergrast (1962). Müller (1951) and Schlee (1969) have described the mycetomes.

Of the several authors who have discussed the position of the Peloridiidae within the Hemiptera the most important contributions are those by China (1962), Schlee (1969) and Cobben (1978).

THE KNOWN FAUNA

SOUTH AMERICA

Peloridium Breddin

Peloridium Breddin, 1897: 10.
Type species: *Peloridium hammoniorum* Breddin.

Peloridium hammoniorum Breddin
Figs 1A, 1B

Peloridium hammoniorum Breddin, 1897: 10.
Nordenskjoldiella insignis Haglund, 1899: 174.

This species, which is the largest and most generalized of all known peloridiids, is the sole one to be recorded as occurring in a fully winged, as well as in a brachypterous, condition. It ranges in length between 5.2 mm (macropterous ♀) and 3.8 mm (brachypterous ♂). Its external structure, apart from that of the head, has been described and illustrated by China (1962), who also listed the localities where it has been found in southern Chile and Patagonia.

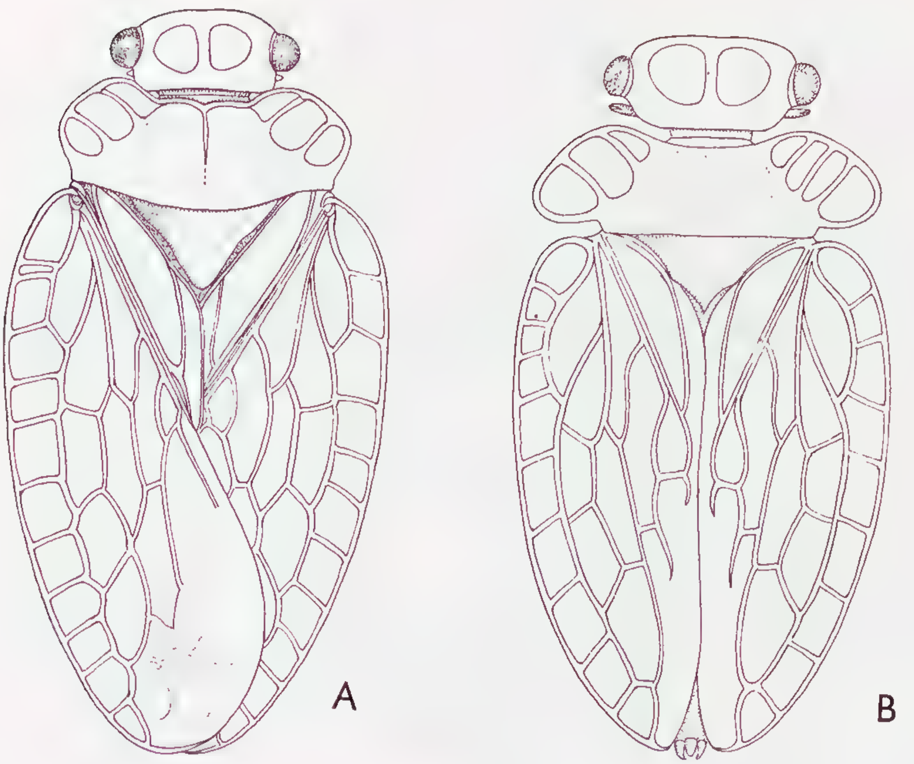

Fig. 1. A, *Peloridium hammoniorum,* macropterous ♂; B, *P. hammoniorum,* brachypterous ♂ (after China, 1962).

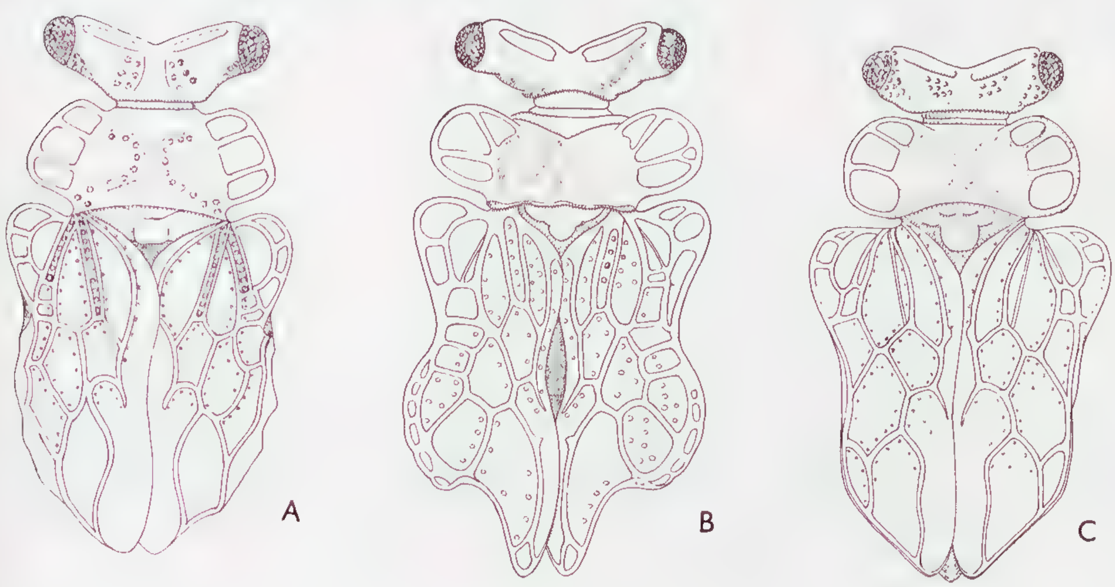

Fig. 2. A, *Peloridora holdgatei,* ♂; B, *P. kuscheli,* ♀; C, *P. minuta,* ♂ (after China, 1962).

Peloridora China

Peloridora China, 1955, 91: 82.
Type species: *Peloridora kuscheli* China.

Peloridora kuscheli China
Fig. 2B

Peloridora kuscheli China, 1955, 91: 82.

Males of this small specialized species are 2.8 mm in length and females 3.3 mm. China (1962), who has described and illustrated the male and female genitalia, recorded some degree of sexual dimorphism. He also listed localities in southern Chile where it has been found.

Peloridora minuta China
Fig. 2C

Peloridora minuta China, 1962, 114: 146.

P. minuta, the holotype male of which is 2.6 mm, differs from *P. kuscheli* in being smaller and in having the forewings less sinuate posteriorly. The male genitalia of the single known specimen, from southern Chile, have been illustrated by China (1962).

Peloridora holdgatei China
Fig. 2A

Peloridora holdgatei China, 1962, 114: 148.

P. holdgatei, which in size is similar to *P. minuta*, differs from it particularly in the shape of the paranota. Both male and female genitalia have been illustrated by China (1942). The two known adult specimens were found on Chiloe Island.

Pantinia China

Pantinia China, 1962, 114: 150.

Type species: *Pantinia darwini* China.

Pantinia darwini China
Fig. 7B

Pantinia darwini China, 1962, 114: 151.

After *P. hammoniorum* this is the most generalized of the South American species. It retains features to some extent shared with an Australian species, *Hemiodoecus leai*, that are lost in other South American representatives of the group. Males are 3.2 mm long and females 3.9 mm. The specimens recorded by China, who has illustrated the male genitalia, were taken on Chiloe Island.

Kuschelia China

Kuschelia China, 1962, 114: 153.

Type species: *Kuschelia edenensis* China

As *Kuschelia* China is preoccupied by *Kuschelia* Malaise, 1949 (Hymenoptera) the new name *Kuscheloides* is proposed for this genus.

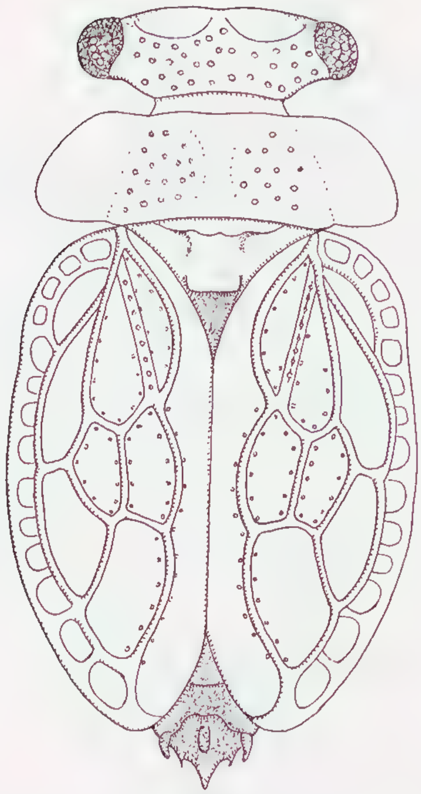

Fig. 3. *Kuscheloides edenensis*, ♂ (after China, 1962).

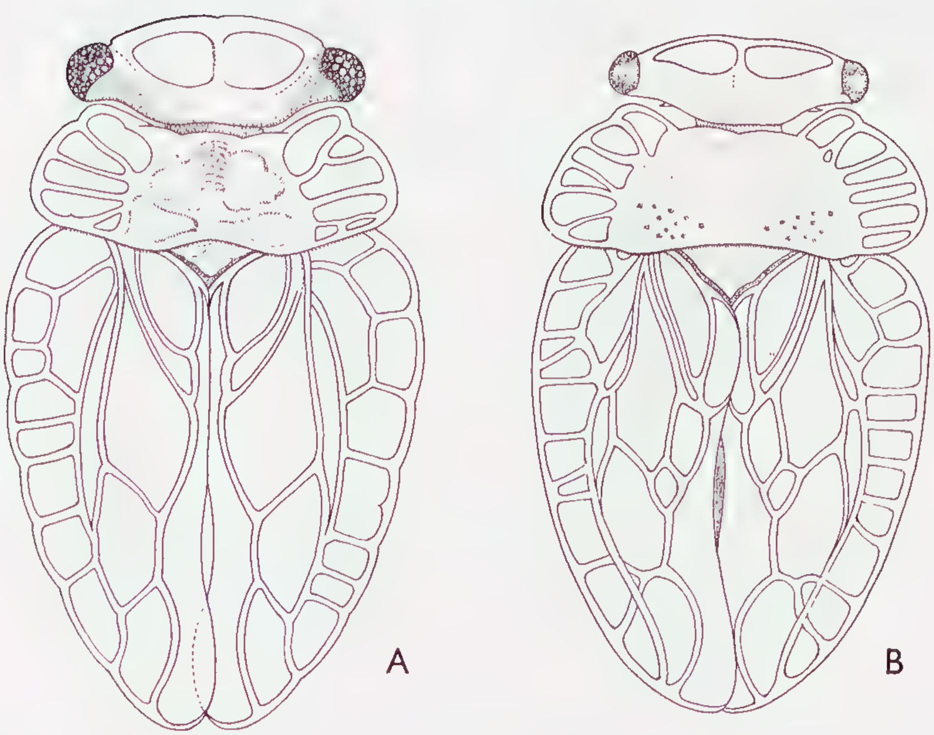

Fig. 4. A, *Xenophyes cascus*, ♂ (Mt. Dewar, N.Z.); B. *X. kinlochensis*, allotype ♀.

Kuscheloides edenensis (China) (comb. nov.)
Fig. 3

Kuschelia edenensis China, 1962, 114: 153.

This species differs from others so far described from South America in lacking distinct cells in the paranota and in exhibiting more extreme brachyptery. Males are 2.9 mm long and females 2.8 mm. The male genitalia have been illustrated (China, 1962). All known specimens were found on Wellington Island.

NEW ZEALAND

Xenophyes Bergroth

Xenophyes Bergroth, 1924, 60: 178.

Type species: *Xenophyes cascus* Bergroth.

The two species assigned to this genus are the most generalized of all New Zealand peloridiids.

Xenophyes cascus Bergroth
Fig. 4A

Xenophyes cascus Bergroth, 1924, 60: 178.

Xenophyes forsteri Drake and Salmon, 1948, 1: 65.

X. cascus, which has a range of distribution extending from the Coromandel Peninsula in the north of the North Island to Stewart Island in the south, is the most widespread New Zealand species. Males are 2.5–3.2 mm in length and females 2.5–3.2 mm. Woodward (1956), who has illustrated the male genitalia, has also listed locality records.

Xenophyes kinlochensis sp. n.
Fig. 4B

Length: ♂, 3mm, ♀, 3.3 mm. Colouration evenly pale brown. Resembling the type species in general appearance but differing in having more veins in both paranota and forewings, and, in particular, in lacking the large cell associated with the absence in *X. cascus* of vein M distal to its junction with CuA.

Holotype ♂ and allotype ♀, New Zealand, South Island, Kinloch, Routeburn Valley, 11-II-57, J.W. and F. Evans (D.S.I.R., Auckland).

Xenophysella gen. nov.

Head with or without areolae. Hind margin of pronotum transverse. Paranota multivenate with external margins slightly rounded. Forewings with or lacking small marginal cells.

Type species: *Xenophyes stewartensis* Woodward.

Xenophysella differs from *Xenophyes* (from which it is probably derived) in the shape of the paranota and the paranotal cells; also in either having smaller marginal cells in the forewing, or lacking them altogether.

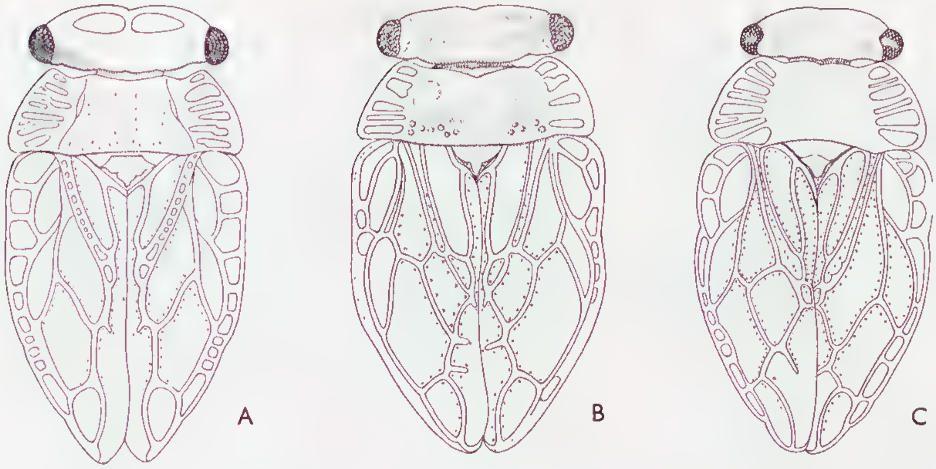

Fig. 5. A, *Xenophysella stewartensis,* holotype ♂; B, *X. pegasusensis,* holotype ♀; C, *X. dugdalei,* holotype ♂.

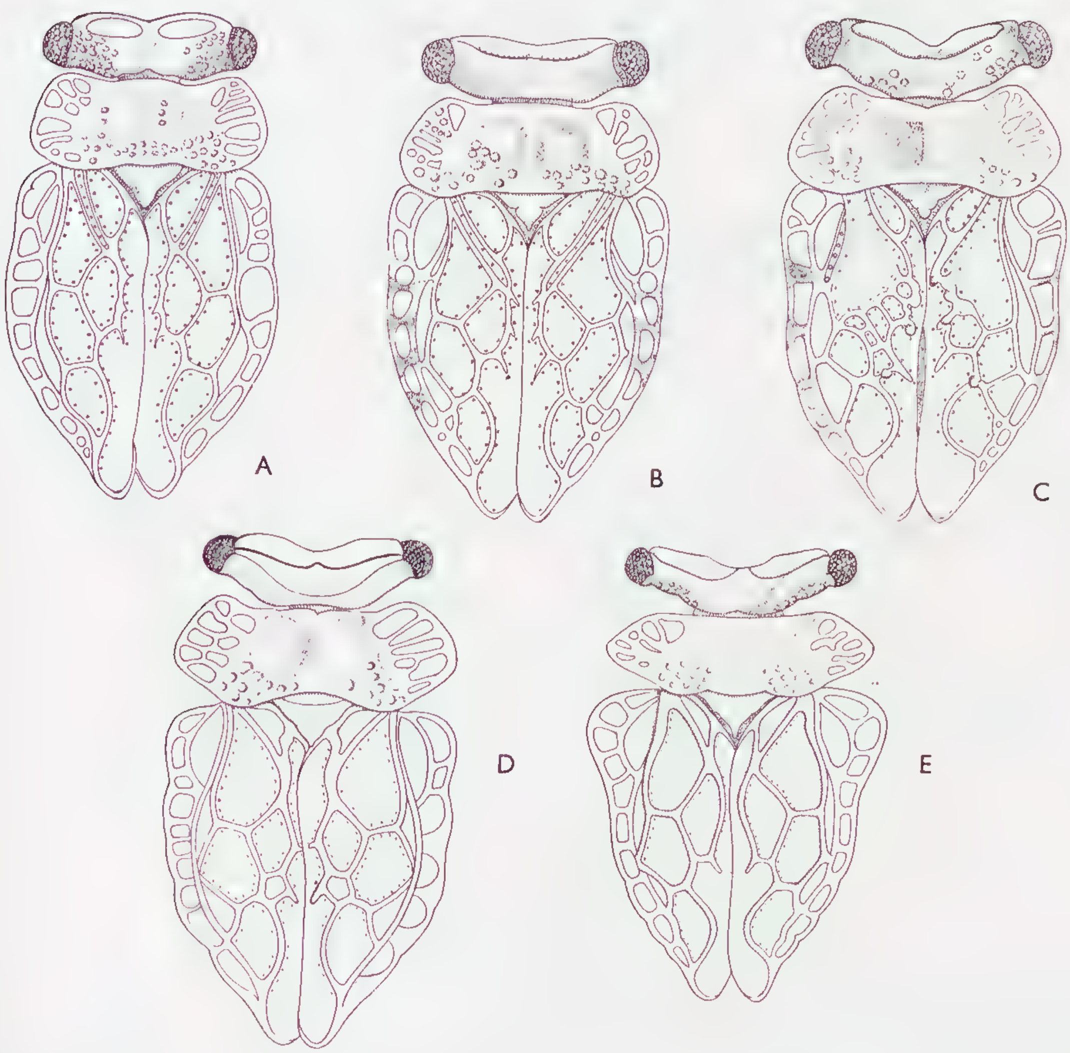

Fig. 6. A, *Oiophysa ablusa,* holotype ♂; B, *O. fuscata,* holotype ♂; C, *O. pendergrasti,* paratype ♂; D. *O. cumberi,* allotype ♂; E. *O. distincta,* holotype ♀.

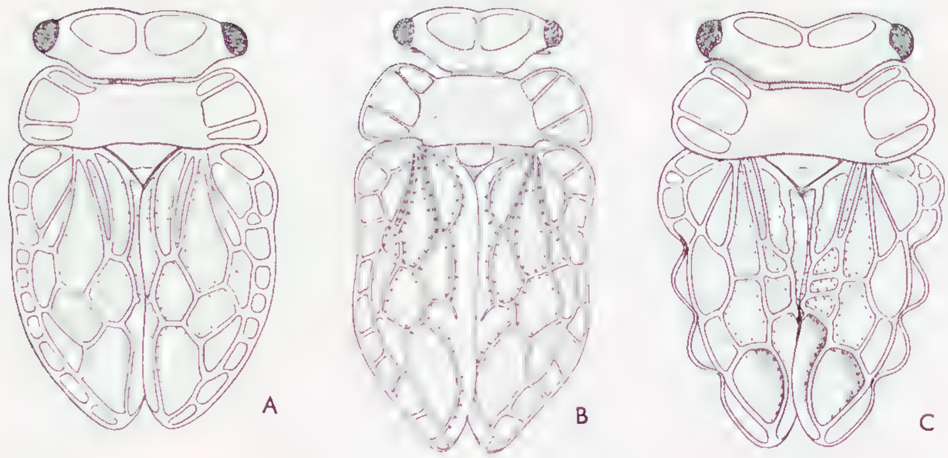

Fig. 7. A, *Hemiodoecus leai*, ♀ (Rennix Gap, Mt Kosciuscko, N.S.W.); B, *Pantinia darwini* (after China, 1962); C, *Hemiowoodwardia wilsoni* (Beech Forest, Victoria).

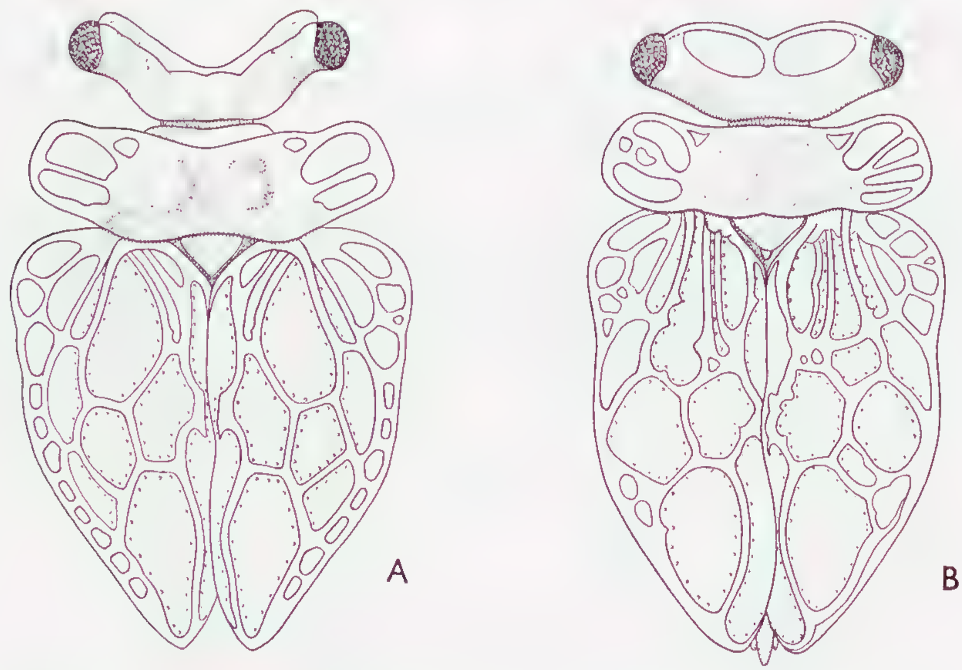

Fig. 8. A, *Hackeriella taylori*, paratype ♀; B. *H. veitchi*, ♀ (McPherson Ranges, Queensland).

Xenophysella stewartensis (Woodward) (comb. nov.)
Fig. 5A

Xenophyes stewartensis Woodward, 1952, 6: 182.

The transfer of this species to a new genus is in accord with the suggestion of Woodward, who has illustrated the male genitalia (Woodward, 1952). Seemingly, it is confined to Stewart Island.

Xenophysella dugdalei sp. n.
Fig. 5C

Length: ♂, 2.4 mm. Colouration pale brown. Resembling the type species in general appearance but differing in lacking well defined cephalic areolae, and in having posteriorly rounded paranota with larger cells and the costal margins of the forewings anteriorly emarginate.

Holotype ♂, New Zealand, South Island, Big Cape Is., N. Peak, 19-II-68, J.S. Dugdale; 1 paratype ♂, same data as holotype, (D.S.I.R., Auckland).

Xenophysella pegasusensis sp. n.
Fig. 5B

Length: ♀, 2.4 mm. Colouration pale yellowish brown. Resembling the type species in general characteristics. Differing in lacking cephalic areolae, and in having fewer paranotal cells and forewings which lack marginal cells posteriorly and have a large cell between veins ScP and Rs + M.

Holotype ♀, New Zealand, Stewart Island, Twilight Bay, Port Pegasus II-45, G. Kuschel; 1 paratype ♀, same data as holotype (D.S.I.R., Auckland).

Oiophysa Drake and Salmon

Oiophysa Drake and Salmon, 1950, 6: 3.

Type species: *Oiophysa ablusa* Drake and Salmon.

Some of the five species assigned to this genus differ very considerably from others. However, as may be seen from the illustrations, a series of intermediate forms link the two extremes as represented by *O. ablusa* and *O. distincta* Woodward.

Oiophysa ablusa Drake and Salmon
Fig. 6A

Oiophysa ablusa Drake and Salmon, 1950, 6: 4.

Both the holotype male and the allotype female of this species are 3 mm in length. They were found on the Leslie Valley Track in the south of the South Island.

Oiophysa fuscata Drake and Salmon
Fig. 6B

Oiophysa fuscata Drake and Salmon, 1950, 6: 6.

The female holotype, which is 3 mm long, was found on lichen in a cave on the Mt Arthur tableland in the north of the South Island.

Oiophysa pendergrasti Woodward
Fig. 6C

Oiophysa fuscata pendergrasti Woodward, 1956, 1 (3): 49.

This insect, which was collected on the Coromandel Peninsula in the North Island, resembles *O. fuscata* in colour pattern but as it differs in head, paranotal and wing characteristics it is considered sufficiently distinctive to merit specific rank. It is moreover smaller than *O. fuscata*, being only 2.5 mm long. The male genitalia have been illustrated by Woodward (1956).

Oiophysa distincta Woodward
Fig. 6E

Oiophysa distincta Woodward, 1952, 6: 184.

O. distincta is the most highly specialized species belonging to the genus *Oiophysa*. The holotype female, which is 2.6 mm long, was found at Caswell Sound in the South Island.

Oiophysa cumberi Woodward
Fig. 6D

Oiophysa cumberi Woodward, 1958, 85: 687.

All known specimens of this species, which is 2.5 mm long, were collected in the North Island. The male genitalia have been illustrated by Woodward (1958).

AUSTRALIA

Hemiodoecus China

Hemiodoecus China, 1924, 60: 199.

Type species: *Hemiodoecus leai* China.

The single described species in this genus, which was the the first to be recorded from the Australian region, retains more generalized features than are present in other Australian peloridiids.

Hemiodoecus leai China
Fig. 7A

Hemiodoecus leai China, 1924, 60: 199.

As well as being the most generalized Australian peloridiid this species is also the one most widely distributed. It occurs in Tasmania, south-east and south-west Victoria, and at high altitudes in southern New South Wales. It varies from 3-3.5 mm in length. The male genitalia have been illustrated by Myers and China (1929).

Hemiowoodwardia Evans

Hemiowoodwardia Evans, 1972, 83: 85.

Type species: *Hemiodoecus wilsoni* Evans.

Hemiowoodwardia wilsoni (Evans)
Fig. 7C

Hemiodoecus wilsoni Evans, 1936, 9: 103.
Hemiowoodwardia wilsoni (Evans), Evans 1972, 83: 85.

This distinctive species would seem to be restricted to the Beech Forest area of western Victoria. Males are 3.2 mm long and females 3.5 mm.

Hackeriella Evans

Hackeriella Evans, 1972, 83: 83.

Type species: *Hemiodoecus veitchi* Hacker.

Hackeriella veitchi (Hacker)
Fig. 8B

Hemiodoecus veitchi Hacker, 1932, 37: 262.

Hackeria veitchi (Hacker), China, 1962, 114: 156.

Hackeriella veitchi (Hacker), Evans, 1972, 83: 83.

H. veitchi lives at high altitudes on the McPherson Ranges on the Queensland-New South Wales border and on Point Lookout in the New England National Park in New South Wales. Males are 3-3.2 mm and females 3.2-3.3 mm. The male genitalia have been illustrated by Helmsing and China (1937).

Hackeriella taylori Evans
Fig. 8A

Hackeriella taylori Evans, 1972, 83: 83.

This species, which occurs on the summit of Mt. Bellenden-Ker (1500 m) in north Queensland, is the first species to be recorded from the tropics. Females are 2.5 mm long.

Hemiodoecellus Evans

Hemiodoecullus Evans, 1959, 25: 61.

Type species: *Hemiodoecus fidelis* Evans.

The sole species now recognized in this genus differs from all other known peloridiids in two distinctive characters. These are bilobed parameres and reticulate paranotal venation.

Hemiodoecellus fidelis (Evans)
Fig. 9A

Hemiodoecus fidelis Evans, 1937, (B) 6: 107.

Hemiodoecus donnae Woodward, 1956, 1 (3): 38 (syn. nov.), (Fig. 9B).

Hemiodoecellus donnae (Woodward), Evans, 1959, 25: 61. (syn. nov.)

H. fidelis, which was originally described from Tasmania, has been found also (as *H. donnae*) in eastern Victoria. Males are 3-3.8 mm long and female insects 3.2-3.8 mm. The male genitalia have been illustrated by Evans (1937) and Woodward (1956).

LORD HOWE ISLAND

Howeria Evans

Howeria Evans, 1959, 25: 58.

Type species: *Howeria kingsmilli* Evans.

Three species ascribed to this genus have been described from Lord Howe Island. The island, which is situated 400 km east of the New South Wales coast, has an area of approximately 1300 hectares and is of volcanic origin. The insects live on the top of Mt Gower which is 760 m in height and has a summit area of some 60 hectares. The three species differ in size and venational characteristics.

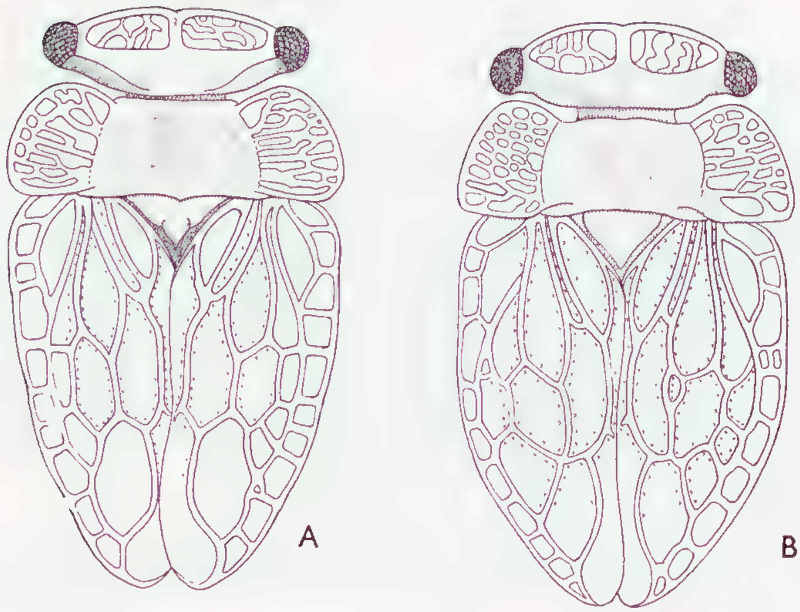

Fig. 9. A, *Hemiodoecellus fidelis*, ♂ (Mt Wellington, Tasmania); B, *H. donnae*, paratype ♂.

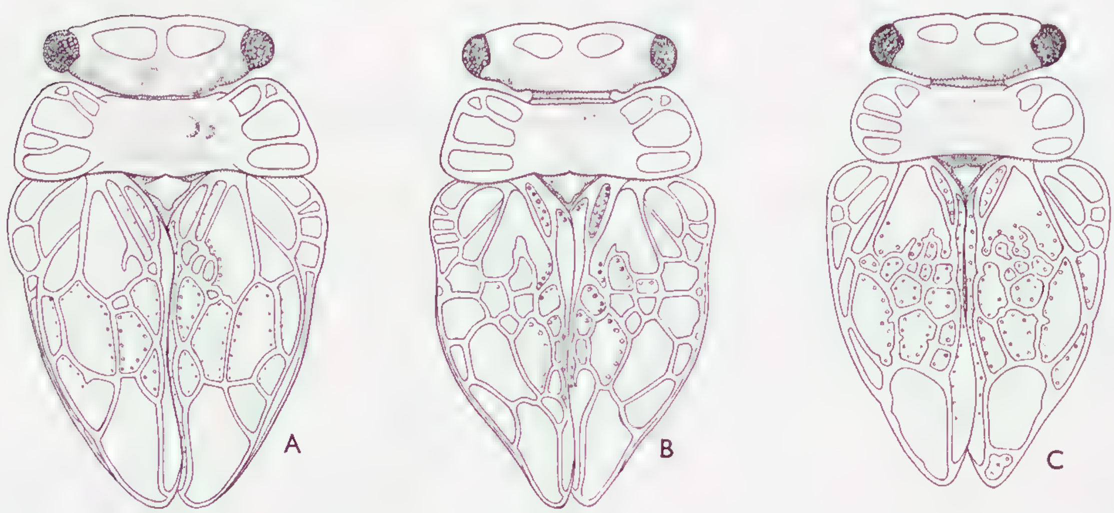

Fig. 10. A, *Howeria coggeri*, paratype ♂; B, *H. kingsmilli*, paratype ♂; C, *H. payteni*, paratype ♂.

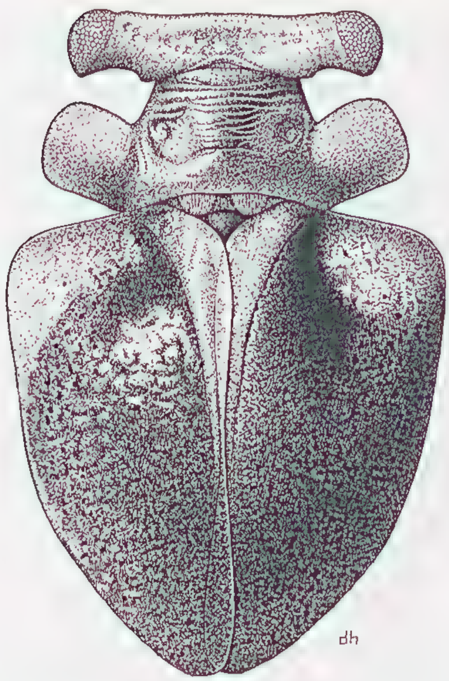

Fig. 11. *Oiophysella degenerata,* holotype ♂.

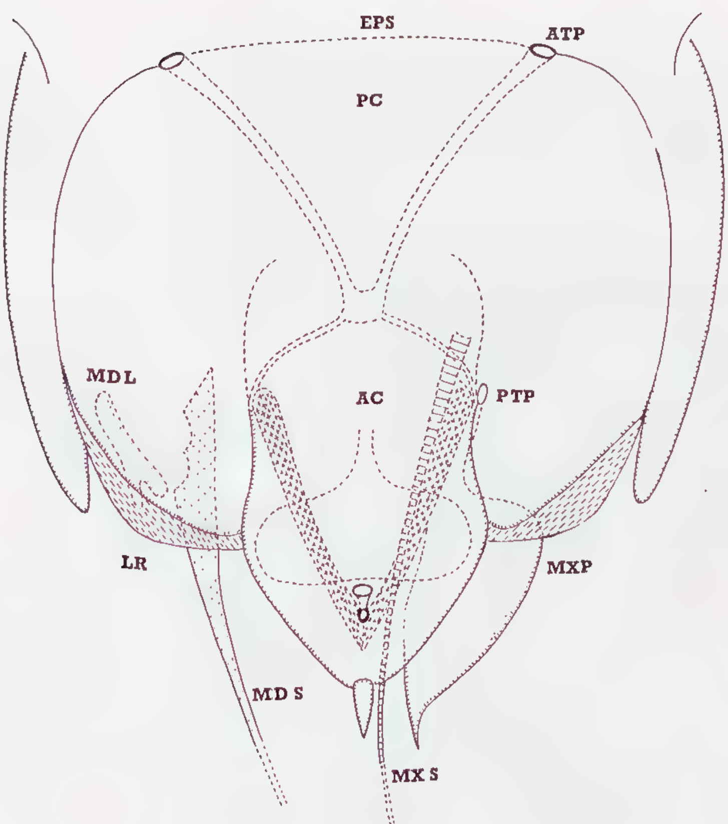

Fig. 12. *Hemiodoecus leai,* anterior portion of adult head. AC, anteclypeus; ATP, anterior tentorial pit; EPS, epistomal suture; LR, lorum; MDL, mandibular lever; MDS, mandibular stylet; MXP, maxillary plate; MXS, maxillary stylet; PC, postclypeus; PTP, posterior tentorial pit.

Howeria kingsmilli Evans
Fig. 10B

Howeria kingsmilli Evans, 1959, 25: 59.

Specimens of *H. kingsmilli* are intermediate in size between the two other island species. Males are 3 mm long and female insects 3.1 mm. The male genitalia have been illustrated (Evans, 1959).

Howeria payteni Evans
Fig. 10C

Howeria payteni Evans, 1959, 25: 59.

This is the smallest of the island species, males being 2.6 and females 2.7 mm long. It is also the one with the most reticulate pattern of venation.

Howeria coggeri Evans
Fig. 10A

Howeria coggeri Evans, 1967, 79: 17.

Having male insects 3.7 mm long and females 4 mm, this is the largest of the island peloridiids.

NEW CALEDONIA

Oiophysella gen. nov.

Face of head: labium long, terminating between hind coxae; anteclypeus convex, anterior tentorial pits obscure; hind margin of vertex transverse, eyes globose. Crown lacking areolae, medially excavate, rugose, hind margin medially and laterally arched. Pronotum transversely striated with a pair of anteriorly directed paranotal lobes widely separated from the eyes. Paranota lacking cells. Forewings convex, elytra-like, almost veinless, sloping steeply downwards posteriorly; traces of veins visible on elevated clavus and of cells on the extensive flattened costal area anteriorly.

Type species: *Oiophysella degenerata* sp. n.

Its beetle-like appearance distinguishes this genus from all other described genera of the Peloridiidae.

Oiophysella degenerata sp. n.
Fig. 11

Length: ♂, 1.9 mm, ♀, 2 mm. Colouration pale and dark shining brown; abdomen and legs very dark brown. Males paler than females, in both sexes the clavus and the flattened costal area of the forewings paler than remainder of wings.

Holotype ♂ and allotype ♀, New Caledonia, Table Unio, 1000 m, near Col d'Amieu, 16-X-78, G. Kuschel, (D.S.I.R., Auckland, held in trust for New Caledonia).

I am informed by Dr Kuschel that the holotype was found while sifting litter from dry ground under shrubs and trees and the allotype in litter from a fairly damp stony surface. The area around Col d'Amieu is covered with rain forest.

The differences which separate *O. degenerata* from all other known peloridiids

are so considerable that its affinities with insects in other genera cannot be surmised. Should, in time, further species be discovered in New Caledonia with a recognizable pattern of venation then the source of the island insects may be determinable.

DISTRIBUTION

Information concerning localities where the several species have been found is given elsewhere in this paper. Some, such as *H. wilsoni*, are apparently confined to a restricted area. Others, for example *H. leai* and *X. cascus,* have a more widespread distribution and occur in areas now widely separated by unfavourable climatic barriers. It is presumed that widespread species are of earlier evolutionary origin than ones with a restricted distribution.

The Peloridiidae, which may have originated in Antarctica, must have been in existence before the break up of Gondwanaland. Now known from Chile, Patagonia, New Zealand, Tasmania, eastern Australia, Lord Howe Island and New Caledonia, they may be expected to live also in moss forests in New Guinea where elements of the southern fauna and flora persist.

Darlington (1965) has suggested that the ancestral forms of peloridiids may have been dispersed by flight. However, it is more probable that the brachypterous forms of previously dimorphic insects became the dominant form prior to their widespread dispersal during the Mesozoic and Tertiary periods, for otherwise as a hindrance to rapid flight paranota would presumably have been eliminated by selection (Evans, 1967).

INTERGENERIC RELATIONSHIPS

Although the Peloridiidae are of undoubted ancient lineage, their period of evolutionary origin is unknown, as no fossils have yet been found which can with certainty be assigned to the family.

They are remarkably stable and though their present populations must have been isolated for very considerable periods of time they have developed no substantial structural differences. With a few exceptions such differences as are readily apparent are associated with changes in the shape of the head and paranota and with reductions in the veins of the forewings. In spite of their general stability, however, peloridiids display considerable intraspecific and individual variability and the veins of one side of an insect are seldom identical with those of the other.

Previous authors have all recognized the Chilean genus *Peloridium* as the one retaining the most generalized features (Woodward, 1956; China, 1962; Evans, 1967). From *Peloridium, Pantinia* could have been derived and could in turn have given rise successively to *Peloridora* and *Kuscheloides*.

Pantinia has also a striking resemblance to the Australian genus *Hemiodoecus;* but as the latter has a more complete venational pattern it could not have been derived directly from *Pantinia*, though it might possibly have evolved from *Peloridium*.

For reasons based on structure and distribution *Hemiodoecus* can be regarded as the earliest evolved Australian genus. Following population isolation it may have given rise to both *Hemiowoodwardia* and *Hackeriella* and possibly as well, in spite of paranotal and genitalia differences, to *Hemiodoecellus*. This implies as has been suggested by Woodward (1956), that reticulate paranota are a secondary rather than a

primary characteristic.

In New Zealand the most generalized genus, *Xenophyes*, could have been derived from a *Peloridium*-like ancestor and, following isolation, then have given rise to *Xenophysella* and *Oiophysa*.

Because of the isolated geographical position of Lord Howe Island the possible affinities of *Howeria* are of particular interest. While seemingly not of New Zealand derivation the structure of the three contained species provides little evidence of relationships with Australian forms, although the generalized features of *Hemiodoecus* do not altogether rule it out as an ancestor.

No suggestions can be made as to the affinities of *Oiophysella* with other genera.

DISPERSAL

It is now generally accepted that the existing southern continents are the separated components of a vast super-continent, Gondwanaland, which at times had a cold humid climate and supported a characteristic fauna and flora. These facts, in general terms, provide an explanation of the present distribution of peloridiids.

There remains for consideration the question of whether the geographical situations where these insects now occur in eastern Australia support relicts of a former continuous biota, now widely separated by zones of unfavourable climates, or whether they were elevated at different times and subsequently colonized by adventitious means.

While the second of these two alternatives seems improbable it requires consideration because of the presence of peloridiids on Lord Howe Island which, as a volcanic "sea-mount", has the nature of an oceanic island.

Though the small size of peloridiids might seem to make them favourable organisms for aerial transport their cryptic habits and high humidity requirements render such a means of transport unlikely. Furthermore, for them to become established in a new environment the previous provision of a very specialized ecological niche is essential.

Accordingly, it is suggested that the presence of these insects on "islands", whether surrounded by sea or by unfavourable climatic zones, is best explained if the islands are regarded as representing relict areas of a formerly widespread biota; that peloridiids are not subject to aerial dispersal and that Lord Howe Island, as well as formerly being much larger than at present, was differently situated in relation to the Australian continent.

EXTERNAL MORPHOLOGY AND INTERNAL ANATOMY

Head

The heads of peloridiids, which lack ocelli except in the macropterous form of *Peloridium hammoniorum*, have several unusual characteristics. For this reason they have featured in many investigations of the morphology of the hemipterous head.

Myers and China (1929) were the first to describe and illustrate the head of an adult insect (*H. leai*). They noticed the absence of a gula, the four-segmented condition of the labium and the presence of prominent pits from which arise the anterior arms of a complete tentorium.

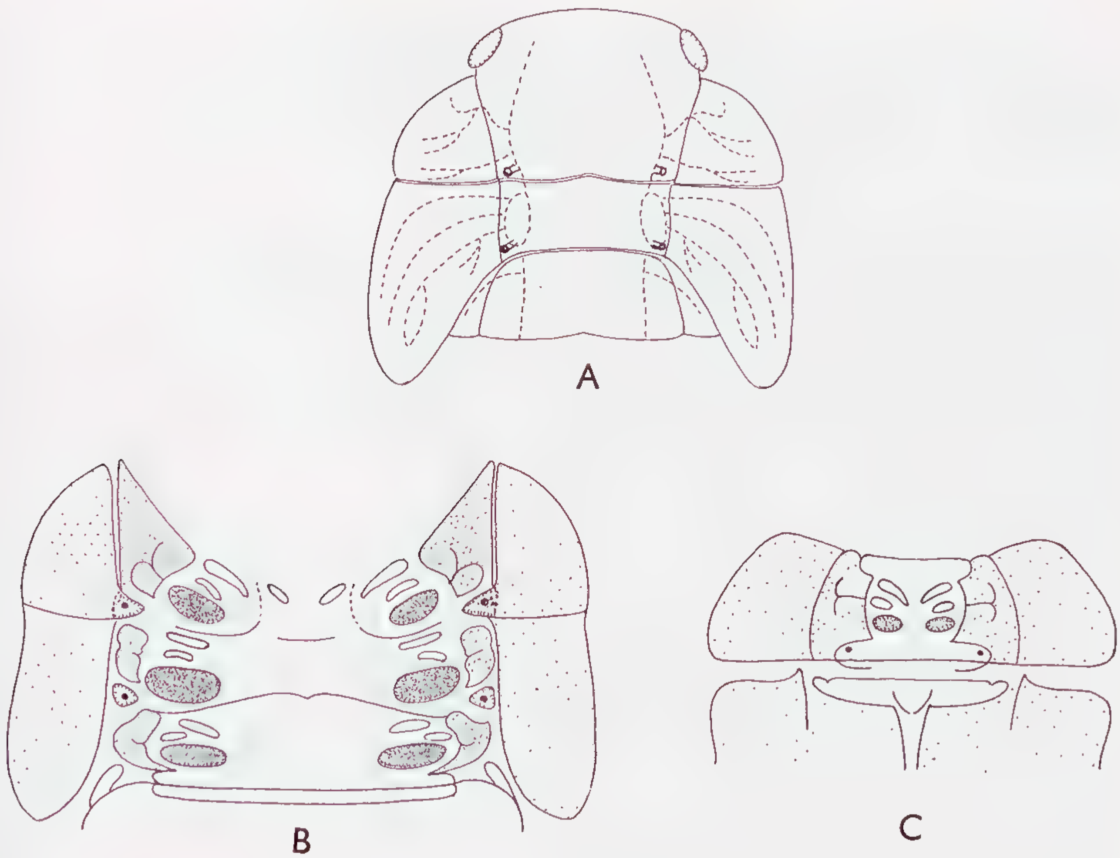

Fig. 13. *Hemiodoecellus fidelis* A, Head and thorax of 4th instar nymph, showing position of spiracles and tracheation; B, the same, ventral surface viewed dorsally; C, prothorax of adult in ventral aspect (after Evans, 1939).

A decade later, in a study of the structure of the heads of Homoptera, I based an interpretation of the origin of the lora, or mandibular plates, on the condition seemingly obtaining in the heads of peloridiid nymphs (Evans, 1937). In this paper, in which the presence of a complete frons in nymphal heads was noted, I suggested that the whole of the lateral lobes of the postclypeus were homologous with the lora of other Hemiptera and hence that these structures were of clypeal origin and not, as subsequently suggested by Snodgrass (1938) and later supported by Parsons (1974), derived from the hypopharynx. Sawai Singh (1969) has pointed out that the true mandibular plates in peloridiids are small structures adjacent to the anterior margins of the clypeal lobes (Fig. 12).

Thorax

The first description of the structure of the thorax of an adult peloridiid was provided by Myers and China (1929). Subsequently, in a more comprehensive account, I noted several features of special interest (Evans, 1939). These included the presence of entosternal arms arising from separate bases; of a pair of spiracles on the prothorax and, in nymphs, the existence of paired dorsal and ventral longitudinal sutures which serve to separate the developing paranota and the wing bases from the rest of the thorax.

In a discussion of the possible significance of these thoracic sutures I suggested they seemed to lend support to the frequently advanced hypothesis that pronotal paranota are homologous with wings and represent an early stage in the development of flying wings. This suggestion seemed to me to be supported by the presence in some species of peloridiids of veins in the paranota which are preceded by tracheae (Fig. 13A).

However, recently Kukalova Peck (1978) has firmly stated that there are no primitively prothoracic lobes which could be logically homologous with wings for these lobes lie well behind the pleural ridges at the dorsal end of which wings would be expected to articulate. Moreover, "the articular attachment of wings in all primitive Palaeozoic nymphs leaves no doubt that solid paranota engaged in gliding did not come first in the evolution of flapping insect wings" and also "wings are movable evaginations of the body wall above the spiracle and below the tergum. Nevertheless, the situation illustrated in Figure 13 is difficult to explain unless in the Peloridiidae wing pads and paranota are in fact homologous.

Paranota are highly variable structures both in shape and in the number of their enclosed cells. Two principal patterns can be recognized; in one the venation is reticulate to a varying degree and in the other three distinct cells are present.

It is difficult to determine which pattern is the earliest for though in one species, *H. fidelis* (Fig. 10A), the veins present in the paranota have been shown to be preceded by tracheae, thus suggesting this may be the primitive condition (Evans, 1939), in others, for example *H. veitchi* (Fig. 8B), the reticulate condition, has clearly been derived from a three-celled one.

Irrespective of whether or not paranota are homologous with wings, they undoubtedly represent an early evolutionary development so they must have a particular evolutionary significance. This is evident from their presence in several Palaeozoic insects belonging to different orders. Their retention in present day insects is infrequent and is largely confined to ones, such as the Myerslopiini and Monteithiini (Homoptera, Ulopinae), which are of ancient lineage and largely flightless (Evans, 1977).

The veins of the forewings of brachypterous peloridiids are raised in relief and the enclosed vitreous or hyaline cells are margined to a varying extent by deep punctures (Fig. 16).

While fully winged specimens of *P. hammoniorum* display the most complete pattern of peloridiid venation a forewing of a brachypterous form has been chosen for illustrating the venation since it allows readier comparison with the wings of other species (Fig. 14A). Beside it is the forewing of *H.leai* (Fig. 14B). This lies in the middle range of progressive vein reduction since, while the costal cells are retained and the clavus reduced, an extensive proximal costal area has been developed.

The principal specializations associated with the development of the brachypterous condition are as follows: a reduction in the size of the costal cells or their elimination (Fig. 2C, *P. minuta*; Fig. 9B, *H. kingsmilli*); the expansion of the anterior costal area (Fig. 6E, *O. distincta*); the development of a sinuate costal margin (Fig. 7C, *H. wilsoni*; Fig. 2A, *P. holdgatei*); a reduction in cell numbers accompanied by an increase in the size of those retained (Fig. 6D, *O. cumberi*); the development of a reticulate condition (Fig. 9C, *H. payteni*); the development of an elytriform condition (Fig. 11, *O. degenerata*).

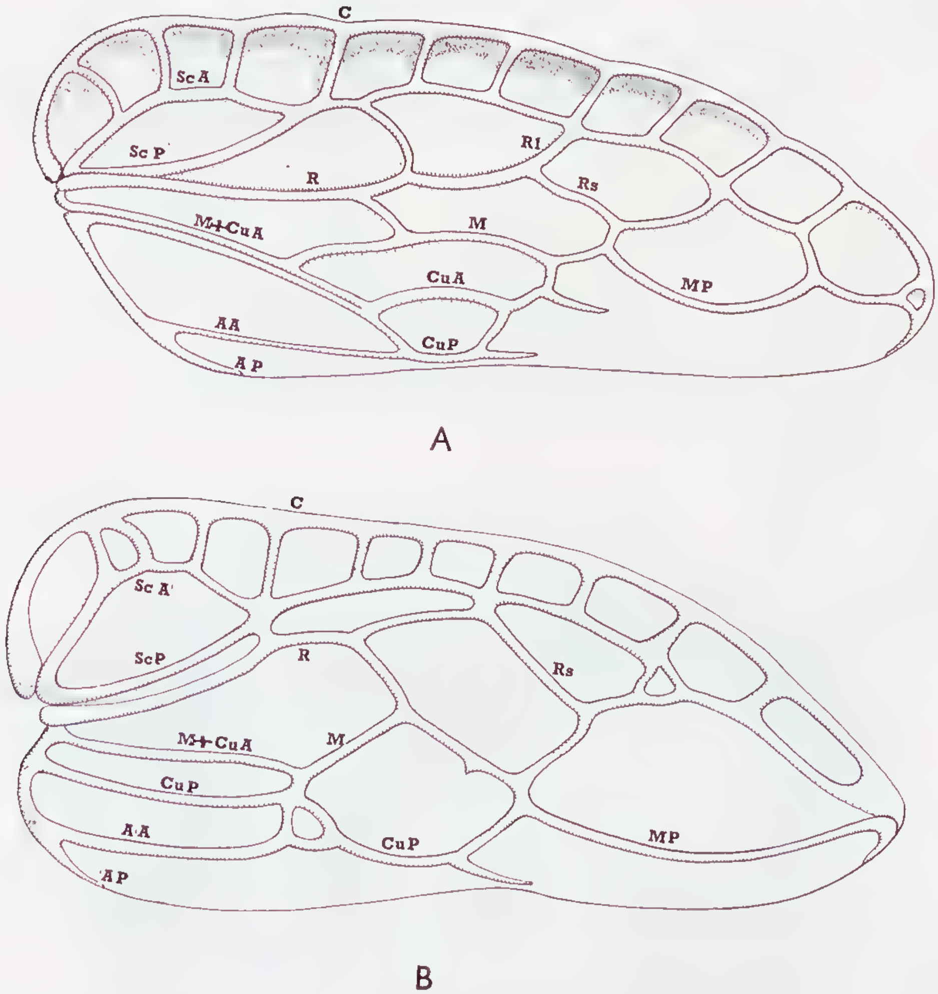

Fig. 14. Brachypterous forewings of A, *Peloridium hammoniorum*, B, *Hemiodoecus leai*.

The interpretation of the venation of the wings illustrated in Fig. 14A, B, for which I am indebted to Dr Peck, differs from my earlier interpretation in several particulars (Evans, 1929, Fig. 8b). The new suggestions must be regarded as tentative as Dr Peck has advised me that vein ScA in Fig. 14 may really represent CP, ScA being absent.

Elsewhere (p. 403) it is mentioned that China (1962) suggested the existence of close affinity between the Triassic Ipsviciidae and the Peloridiidae, and that I had expressed disagreement with this suggestion (Evans, 1963). In this connection it is of interest to note that the Peloridiidae and an ipsviciid, *Ipsviciopsis elegans* Tillyard, share a venational feature which as far as I know occurs elsewhere only in the forewings of a few other Hemiptera. These belong to the fulgoroid families Flatidae, Nogodonidae and Ricaniidae. This feature is the presence of a markedly concave ScP. However, while in the Peloridiidae ScP is separated from the costal margin by a series of large cells, in *I. elegans* it is not. A further venational feature the Peloridiidae share with *I. elegans* is the common stem of M and CuA.

Regarding the hind wing, which in the Peloridiidae, unlike the Ipsviciidae, lacks a marginal vein, China (1962) has pointed out that the wing coupling device of peloridiids is similar to that of many Heteroptera but that in the hind wing there is no forking of the cubital furrow such as is usual in insects in this suborder. He also suggested that the legs, which have two tarsal segments, are heteropterous in character apart from the fact that they have a well developed trochantin.

Abdomen

China (1962) noted that the abdomens of peloridiids, which are dorso-ventrally flattened, resemble those of several Heteroptera, even though in lacking scent glands they differ from many groups in this suborder. The same author recorded the presence of minute scattered trichobothria on the abdomen of *P. hammoniorum* and sensory organs on each side of the ventral surface of segments II-VI. He suggested that the cylindrical anal tube (segment X) with its invaginated anal style was a typical homopterous development.

Woodward (1956) has discussed the abdominal characteristics of peloridiids in relation to possible inter-generic relationships and the male genitalia have been described and illustrated by Myers and China (1929), China (1937, 1962), Woodward (1956, 1958) and Evans (1937, 1959).

Those of the male consist of a large genital capsule, the pygophore (segment IX) (Fig. 15A), from which arise a simple aedeagus and a pair of parameres, or harpogones, associated basally with a triangular or Y-shaped connective or basal plate (Fig. 15B). The parameres, which are usually elbowed, may be cylindrical, club-shaped, or laminate, and in one species (*H. fidelis*) they are branched.

In the light of the known evolutionary plasticity of the male genitalia of insects the differences between populations of peloridiids which have been widely separated for a very long time are surprisingly small and it is suggested that while their study may sometimes be useful as a guide in establishing relationships it is generally of less importance than other available structural characteristics.

The female genitalia which are of a generalized nature need no special comment other than to remark that Woodward (1956) has noted that the first valvulae of species in the New Zealand genera *Oiophysa* and *Xenophyes* differ in their dentition from those of Australian species.

Respiratory System

The tracheal system of the thorax has been described by Evans (1939) and more comprehensively by Pendergrast (1962). The former discussed the possible significance of the presence of spiracles on the first and second thoracic segments and suggested that tracheae entering the pronotal paranota were the precursors of veins.

Woodward (1956) noted spiracles on abdominal segments 1 and 3–8, while Pendergrast, who gave a complete account of the tracheal system, recorded an additional pair of abdominal spiracles bringing the total to the primitive number of 10 pairs.

Nervous System

Pendergrast (1962) has described the gross anatomy of the central nervous

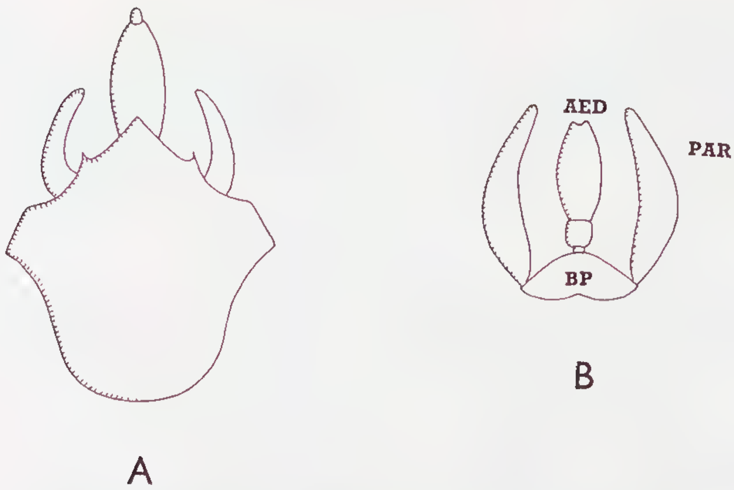

Fig. 15. ♂ genitalia of *Kuscheloides edenensis* (after China, 1962). AED, aedeagus; BP, basal plate; PAR, paramere.

Fig. 16. *Hemiodoecus fidelis* (photograph by Howard Hughes).

system. There are four ventral ganglia and he suggested that though in its concentration of the metathoracic and abdominal elements in one large ganglion the nervous system is typically hemipterous in character, it is unusual in having separate pro- and mesothoracic ganglia since in most Hempitera a greater degree of concentration occurs.

Salivary Glands

The salivary glands have been described by Pendergrast (1962) who considers their simple outline is reminiscent more of some Heteroptera than of the usual complex structures found in the Homoptera. However, while the glands of peloridiids consist of two pairs of complex glands those of the Heteroptera consist of a pair of basically two-lobed ones and a pair of accessory glands (Goodchild, 1966).

Alimentary Canal

Evans (1937), who recorded a simple intestine in peloridiids, noted the absence of a filter chamber and the presence of four malpighian tubes. Pendergrast (1962) gave a more detailed description of the alimentary canal, which according to Goodchild (1966) is more primitive than that of any other living Hemiptera and strikingly similar to that of Thysanoptera.

Mycetomes

These have been described by Müller (1951), Pendergrast (1962) and Schlee (1969).

ENVIRONMENTAL REQUIREMENTS

Generally speaking peloridiids require high moisture conditions though they seem able to survive periods when these do not prevail. While these insects usually inhabit saturated moss they can be found elsewhere when rain is falling.

Anyone collecting peloridiids soon becomes aware they are largely confined to particular mosses even in environments where an abundance of species of these plants occur. The following mosses have been recorded as harbouring peloridiids: Chile, *Pohlia cruda* (China, 1962); New Zealand, *Psilopilum crispulum* (Carter, 1950); Australia, *Papillaria kermadecensis* (Helmsing and China, 1937); Lord Howe Island, *Spiridens vieillardi* (Evans, 1967). They have also been found in sphagnum bogs in Tasmania and New South Wales, on lichens in New Zealand (Drake and Salmon, 1950), and on *Madotheca stangeri*, a moss-like hepatic, on Lord Howe Island (Evans, 1967).

FACTORS DETERMINING ABUNDANCE

Doubtless the principal factor most favouring peloridiid populations is the occurrence of suitable mosses situated in permanently wet environments. These for instance are provided by sphagnum growing beside a permanently flowing stream. Less favourable conditions are provided by suitable mosses growing in environments liable to periodic desiccation.

Insects are frequently found covered by a fine grey film which may be removed like a skin. Its effects, if any, on the insects are unknown. Helmsing and China (1937) have recorded a fungus belonging to the *Uncinula* group on specimens of *H. veitchi* and a lethal fungus (*Cordyceps* sp.) in specimens kept in captivity.

While no internal or external insect parasites have been recorded, potential predators which occur abundantly in wet moss must take their toll. These include centipedes, pseudoscorpions, spiders, beetles and Heteroptera.

BIOLOGY

Both adults and nymphs, which are cryptically coloured, walk with a slow awkward motion. The former if disturbed lie on their backs and rest quiescent for a short period. They avoid bright light (Evans, 1937).

Nymphs have been described and illustrated by several authors, in particular by Helmsing and China (1937), Evans (1939) and China (1962). There are four nymphal instars.

THE FLIGHTLESS CONDITION

It did not need the discovery of specimens of *P. hammoniorum* with fully developed hind wings to establish, even though all other known species have apparently lost the power of flight, that peloridiids once flew. Whether they lost the power of flight before or after the break up of Gondwanaland cannot be known with certainty but previously (as already mentioned) I have suggested that sub-brachypterous forms may have become the dominant ones prior to the widespread dispersal of these insects (Evans, 1967).

Southwood (1961) has pointed out that brachypterism is frequently associated with high altitudes where prevailing low temperatures act on the hormonal balance and lead to the production of metathetelous adults (adults which retain juvenile characters).

SYSTEMATIC POSITION

When first defined by Breddin (1897) the Peloridiidae were referred to the Heteroptera and regarded as having possible affinity with the Ochteridae. Here they remained until Myers and China (1929) in a detailed study of *H. leai* transferred them to the Homoptera and assigned them to a new series, the Coleorrhyncha.

Later Bekker-Migdisova (1958) suggested they might be related to a family of extinct Heteroptera, the Cicadocoridae. This family, which has been referred to in the literature also as the Eocimicidae and the Actinoscytinidae, is now on grounds of priority known as the Progonocimicidae (Popov and Wootton, 1977). It contains some of the earliest known certain Heteroptera and has been recorded from Triassic strata in the southern, and Liassic strata in the northern, hemisphere. In venational characteristics the Progonocimicidae have some resemblance to early Homoptera.

Although, as pointed out by China (1962), the Peloridiidae are very doubtfully related to the Progonocimicidae it is of interest to note that a Middle Triassic fossil from Queensland (*Triassodoecus chinai* Evans) that has been referred to this family possesses well developed pronotal paranota (Evans, 1963).

In the paper referred to above China suggested that the Peloridiidae were related to another group of Triassic Hemiptera from Queensland, the Ipsviciidae, and in fact that they were actually "modern ipsviciids which had changed little since Triassic times". He further suggested that the Peloridiidae should be transferred to the Auchenorrhyncha.

In a later discussion of the systematic position of the Ipsviciidae I suggested they were best regarded as a family of the Cercopoidea and most certainly lacked close affinity with the Peloridiidae (Evans, 1963).

In the opinion of Schlee (1969) the Peloridiidae are a sister group of the Heteroptera, both suborders being comprised in a superorder, the Heteropteroidea. He suggests that the characteristics on which Myers and China (1929) based their claim that they were predominantly homopterous lacked validity when examined in terms of whether they were plesiomorphic, synapomorphic or convergent. Cobben (1978) however regards the synapomorphies selected by Schlee to establish the monophyly of the Heteroptera + Coleorrhyncha as superficial and probably without significance.

In any assessment of the characteristics of the Peloridiidae made for the purpose of seeking to determine their position within the Hemiptera plesiomorphic features

need first to to be recognized. Otherwise there is a possibility of their being unjustifiably used in support of claims for special affinity with either the Homoptera or Heteroptera.

Accordingly, while the primitive features listed below are ones particularly associated with the Homoptera they need not necessarily be an indication of especially close affinity with insects in this suborder:

A deflexed head with a long labium; prominent anterior tentorial pits; a complete tentorium; in nymphs a well defined epistomal suture; no gula; separate pro- and mesothoracic ganglia; in the male genitalia, parameres articulated with a Y-shaped basal connective.

Likewise the following features, though ones particularly associated with the Heteroptera, may be no more than generalized features no longer retained in the Homoptera:

A large prothorax; a flattened abdomen covered by horizontal wings; an intestine lacking a filter chamber; in the female a small number of ovarioles.

The following characters, so far as I am aware, are entirely or almost entirely restricted to the Peloridiidae:

Very small anteriorly situated mandibular plates; extensive pronotal paranota; in nymphs, both dorsal and ventral longitudinal sutures, which serve to separate the paranota and the wing pads from the rest of the thorax.

As present evidence seems inadequate to permit the certain association of the Peloridiidae with either the Homoptera or the Heteroptera they are probably best regarded as constituting a suborder of the Hemiptera comparable with the Homoptera and Heteroptera. For this the term "Peloridoptera" is proposed as being preferable to the ordinal name "Peloridiidina" suggested by Weber and Weidner (1974), on the grounds that the termination "-ina" as a group ending has but limited recognition.

ACKNOWLEDGEMENTS

I am grateful to Dr G. Kuschel of the Entomology Division of the Department of Scientific and Industrial Research, Auckland, New Zealand, for the privilege of being permitted to study the first peloridiid to be recorded from New Caledonia, and for the loan of a paratype of *Oiophysa cumberi* and a large collection of New Zealand peloridiids.

Thanks are also expressed to Mr R.A. Savill of the Canterbury Museum for the loan of holotypes of *Oiophysa distincta* and *Xenophyes stewartensis*; to Mr R.G. Ordish of the National Museum, Wellington for the loan of the holotypes of *Oiophysa ablusa* and *O. fuscata*; to Dr G. Monteith of the Queensland Museum for the loan of a paratype of *Oiophysa pendergrasti*; to Dr J. Hickman of the Department of Zoology, University of Tasmania for the gift of a large collection of Tasmanian peloridiids and to Dr J. Kukalova Peck, of the Department of Geology, Carleton University, Canada for an interpretation of the venation of *Peloridium hammoniorum*.

All the illustrations except that of *Oiophysella degenerata*, which is the work of Mr. D.W. Helmore of the D.S.I.R., Auckland, were prepared by my wife.

In conclusion I would like to put on record my deep debt to the late Dr W.E. China to whom I owe so much and who over a period of many years, made such a notable contribution to knowledge of the Peloridiidae.

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LONG ISLAND, PAPUA NEW GUINEA: INTRODUCTION

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DEDICATION

This series of papers is dedicated to the memory of R. J. S. Cooke, who was killed by a volcanic eruption on Karkar Island on 8 March, 1979. Professionally, Rob Cooke was a volcanologist, but even more impressive than his excellent work on volcanoes was the depth and breadth of his interest in Papua New Guinea, for he was also an expert on New Guinea birds and on New Guinea history. His helpfulness and his critical abilities will be sorely missed by all of us who had the pleasure of working with him.

SUMMARY

Long Island, in the Madang Province of Papua New Guinea, forms part of the Bismarck Volcanic Arc. Most life on the island was apparently destroyed in a catastrophic eruption during the 17th or early 18th century, and the island has subsequently been recolonized by plants, animals and humans. The human population of the island is still small enough to make possible significant studies of the relation between the expanding human population and the environment. In addition, creation in 1968 of a volcanic island in the large freshwater lake filling the central caldera of the island has allowed observation of a colonization process essentially from the start. Between 1969 and 1978 the authors were engaged on research into various aspects of the island's eruptive and human history. This paper provides a general introduction to these studies which are more fully described in the following papers.

Long Island, known as Pono to its inhabitants and as Arop or Ahrup to people on the New Guinea mainland, lies about 130 km east of Madang and 65 km north-east from Saidor in the Madang Province of Papua New Guinea (Fig. 1). The island is part of the Bismarck Volcanic Arc, a series of Quaternary volcanic centres running from the Schouten Islands in the west to Rabaul on New Britain in the east. Some 900 people speaking an Austronesian language inhabit the island, most of them in the five main settlements of Bok, Kaut, Malala, Poin Kiau and Matapun.

The island was given its English name by Dampier, who sailed past it in AD 1700. However, it is roughly hexagonal in plan, with a maximum width of about 30 km and a land area of about 328 km^2 (Fig. 2). It has a central caldera lake, Lake Wisdom, (area 86* km^2) at each end of which an extinct volcanic cone rises over 1,000 metres. The island has a variety of habitats which reflect the altitudinal range (Figs. 3—6).

*This figure has been given elsewhere (e.g. Ball & Glucksman 1978) as 95 km^2 based on the 1:63360 U.S. Army Corps of Engineers Provisional Map, Long and Crown Islands B55/6 and 7 (1943). However, on the basis of Papua New Guinea 1:100,000 Topographic Survey Sheet 8387 (1977) the figure should be 86 km^2.

Records of the Australian Museum, 1982, **Volume 34 Number 6**, 407–417, Figures 1–6.

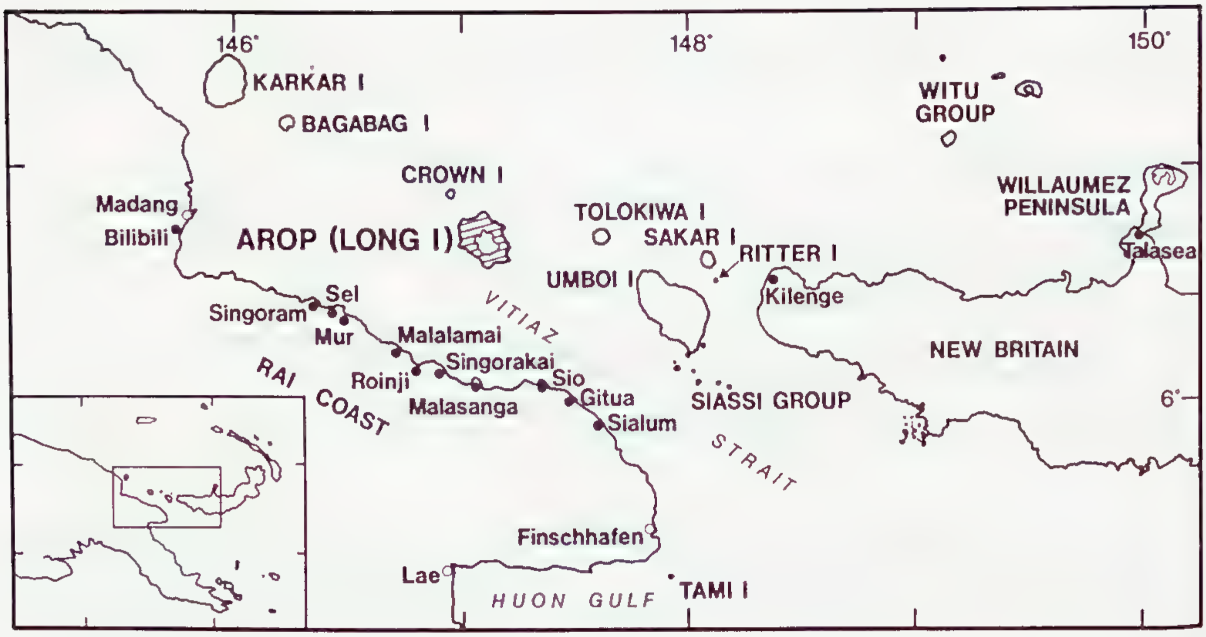

Fig. 1. Map of the area surrounding Long Island showing localities mentioned in the text.

According to both geologists (Blong, Pain and McKee 1982) and local legends (Ball and Hughes 1982) the last major eruption of Long Island devastated most or all life there. The exact date of this eruption is problematical, for there was no evidence of recent devastation when Dampier sighted the island in AD 1700 or when Dumont D'Urville sailed past in AD 1827. Ball and Johnson (1976) concluded, on the basis of evidence available to them in 1975, that the eruption most likely occurred sometime during the first half of the eighteenth century. But an earlier date is possible. Blong (Appendix 1 of Blong, Pain and McKee 1982) concludes that the eruption took place sometime between 1630 and 1670. Until more evidence is obtained it seems safe to assume that the eruption occurred between 1630 and 1800 which is quite recent as far as the colonization processes considered below are concerned. Thus, if the island was as completely devastated as appears to have been the case this should be reflected by abnormalities in the flora and fauna due to the short time available for colonization. Diamond (1974) has found just such an abnormality in the avifauna which is drawn disproportionately from 'supertramp' species which are specialists in rapid reproduction and over-water colonization. In addition, the colonists are drawn disproportionately from species which have successfully colonized New Britain and the surrounding islands rather than from the New Guinea mainland.

Krakatoa, in Indonesia, and Surtsey, off Iceland, are probably the best-known studies of colonization of a new volcanic island. However, in the case of Krakatoa detailed studies of the colonization process were not undertaken until twenty-five years after the event, during which period many significant happenings would have gone unrecorded. Surtsey, in contrast, was carefully monitored from its beginnings and had the advantage that the species pool of potential colonists was well-known. However, biologically the colonization of Surtsey is of less interest because it is a temperate island with a limited species pool from which colonists could be drawn. Long Island, too, presents advantages and disadvantages to the student of colonization. The main disadvantages are: (1) the exact date of the eruption is not known, (2) the completeness of sterilization is not known, and (3) the species pools of New Guinea, New Britain and the surrounding islands, from which colonists could be drawn, are poorly known. The principal advantage appears to be that the diversity of potential colonists makes the process of colonization of great interest so that as more

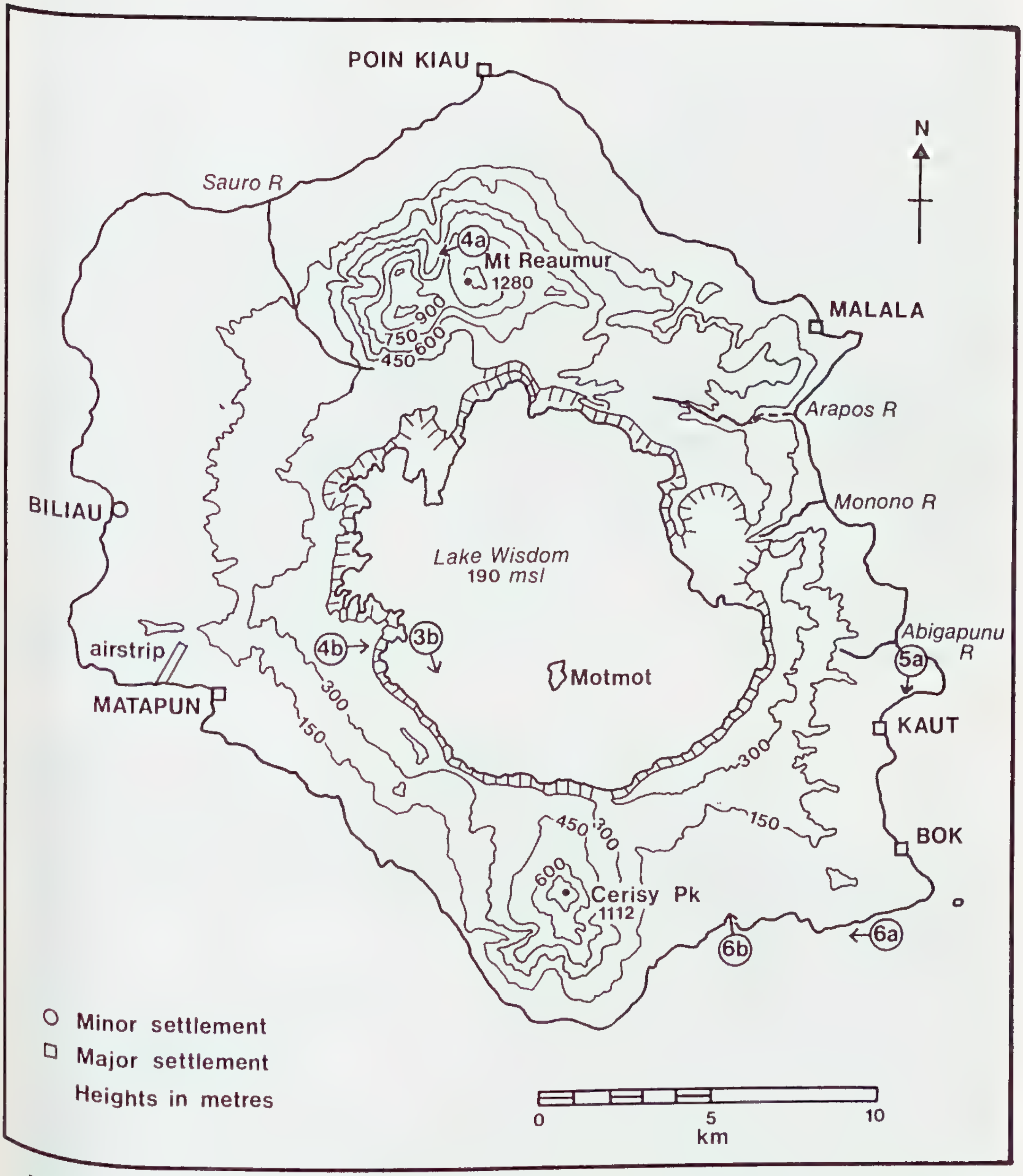

Fig. 2. Map of the major geographic features and settlements of Long Island. Numbered arrows show location and direction of view of corresponding figure.

a

b

Fig. 3. The general setting. A. From the sea a 'long' island. Mt. Reaumur to left, Cerisy Peak to right. B. Lake Wisdom and Cerisy Peak, as viewed from the northwest.

a

b

Fig. 4. The top of Long Island. A. Cloud forest near the summit of Mt. Reaumur. B. Motmot and Lake Wisdom , as viewed from the west rim of the caldera.

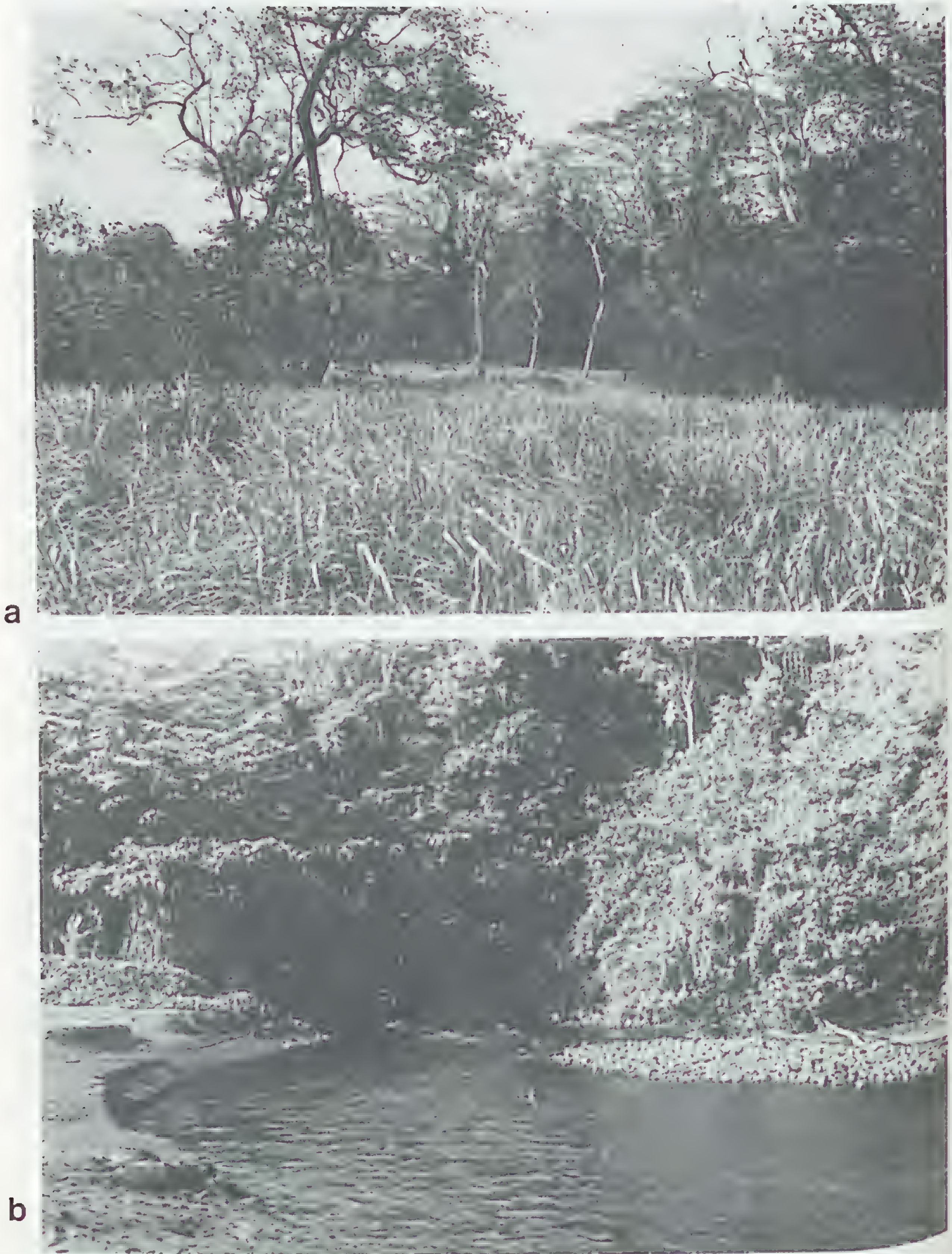

Fig. 5. Habitats of Long Island — the east coast. A. 'Kunai' (*Imperata cylindrica*) north of Kaut. B. Monono River at the sea.

a

b

Fig. 6. Habitats of Long Island — the south coast. A. Ash cliffs near Soraga, Cerisy Peak in background. B. Brackish lagoon and pandanus just behind beach to the west of Soraga.

is learned about the faunas of surrounding islands many interesting features of the successful colonists may be revealed.

Perhaps even more significant is the opportunity for watching the process of human colonization of a new environment. Here, we seem to be in a somewhat better position with regard to our starting point because there is unanimous agreement among the present inhabitants that there was no one on the island when their ancestors came. In addition, the present inhabitants have legends about the first colonists and we have observations of passing explorers as to the level of human population at different times. From this information, combined with government patrol reports since World War II, it has been possible to document human population growth and the increasing pressure on natural resources which this has caused (Ball and Hughes 1982). In addition, Long Island provides an opportunity for students of social change because until World War II the people lived largely in the traditional way, while since that time they have become steadily more involved with the outside world.

The best opportunity for answering several important questions about the early stages of colonization has passed on Long Island. However, Motmot, a secondary cone which has formed an island in Lake Wisdom, has made it possible to study some of these questions on a smaller scale. Motmot was created in an eruption in 1968 and since that time has been studied by Ball and his co-workers (Bassot and Ball 1972; Ball and Glucksman 1975, 1978, Ball 1977). The following groups of organisms has reached Motmot — plants with light seeds and spores and invertebrates capable of aerial rafting, animals capable of surviving in or on floating vegetation and plants with floating seeds, plants eaten by black ducks, seeds eaten by the prey of falcons which, subsequent to capture, have been carried to the island and torn apart, and animals capable of flight. In general those plants which have survived best on Motmot are characteristically found in disturbed areas around the lake while the most successful animals are omnivores or are capable of going for long periods without food. Another interesting feature of Motmot is that a series of volcanic eruptions in 1973-74 created what is almost a replicate recolonization situation with higher plant recolonization starting again from three specimens of a single species. Further details can be obtained from the papers listed above.

This volume consists of a collection of papers relating to the history of Long Island and its inhabitants. The various aspects of research described here were not planned as in inter-disciplinary project. The authors began by working in their own fields of expertise, but by mid 1976 the various individual projects were so intertwined that a joint publication was decided upon. By that time it had become apparent that there was a general need for a summary of all that was known about Long Island, especially in the areas of geological and human history.

Ball, a member of the 1969 *Alpha Helix* expedition, began a study of the biological colonization of Motmot in Lake Wisdom, after it had been sterilized by volcanic activity in 1968, and of the apparently simple biota of the lake itself. Initially, this work was in conjunction with J. M. Bassot (Bassot and Ball 1972), but was subsequently continued by Ball and J. Glucksman who visited the island annually from 1971 to 1974 and again in 1976 (Ball and Glucksman 1975, 1978). Ball returned to the island in 1978 with McKee. In an attempt to determine the age of Lake Wisdom and the history of Motmot, Ball reviewed all available sources concerning Long Island's history, and prepared an exhaustive manuscript.

Archaeological interest was aroused by the discovery in 1969 of human bones and potsherds eroding from beneath substantial deposits of volcanic materials on the

coast (J. Womersley, cited in Bassot and Ball 1972:27). Johnson *et al*. (1972:48) in citing Womersley suggested that the bones might represent islanders killed in the cataclysmic eruption that is remembered in Long Island legends. A prospecting geologist, J. Wood, reported further finds of artefacts and human bones in 1970. These finds were investigated by Hughes in 1972 when he visited the island with a party from the Department of Agriculture, Stock and Fisheries of Papua New Guinea (D.A.S.F.) to carry out a preliminary land-use survey. Hughes visited two coastal archaeological sites (JAB and JCB), each of which had sherds and obsidian flakes eroding from levels within the volcanic deposits, and collected samples of carbonised wood for radiocarbon dating from exposures in the north-west coastal cliffs.

In 1972-73 Specht and Egloff independently began archaeological and ethnographic research in the Sio-Gitua and Madang areas respectively. Each was concerned with aspects of recent and prehistoric pottery production and trading activities in their areas. Since Long Island was linked with both areas through trade and mythology, they felt that a joint investigation of the island's archaeological finds would be of mutual benefit.

In May-June 1973 Hughes, Egloff and Specht were joined by scientists from D.A.S.F. and the National Parks Board of Papua New Guinea for a further investigation of the island. Using the M. V. *Koro* out of Madang for transport and a working base, four days were spent visiting three archaeological sites on Long Island. Time did not permit excavation of the deeply-buried deposits but artefacts, shells, bones and further ^{14}C samples were collected.

The age determinations from Hughes' 1972 ^{14}C samples bridged those associated with the Tibito Tephra (formerly 'Z' ash) found in upper levels of prehistoric agricultural systems in the Wahgi Valley of the New Guinea Highlands (later published in Golson 1976). While collaborating on that project in 1973, Hughes suggested that a visit to Long Island by those investigating the ash stratigraphy of the Wahgi might be profitable to both investigations. Subsequently, Blong (1975) proposed Long Island as one of several possible sources for the Tibito Tephra.

In 1976 McKee visited Long Island twice as part of a continuing geological and geophysical study. On the first of these visits he was joined by Blong and Pain, who examined the tephrostratigraphy of the north and west coasts. McKee and Ball in 1978 collected further archaeological materials and information. These various studies have permitted the refining of the stratigraphy outlined by Johnson and his colleagues (1972; *cf*. Ball and Johnson 1976), the collection of additional ^{14}C samples for earlier phases of the island's volcanic activity, and have clarified the stratigraphic positions of the archaeological sites studied by Egloff, Hughes and Specht.

The first paper, by Blong, Pain and McKee, presents an outline of the island's landforms and a brief history of the pyroclastic mantle. Little is known of the island's history prior to about 16,000 years ago, when the first of three major eruptive phases was under way. The second occurred about 4,000 years ago, and the third probably in the first half of the 17th century according to Blong's estimate. The effect of this last phase, in particular, on human settlement is briefly discussed. This is followed by a review of the archaeological data by Egloff and Specht, who describe sites which were occupied before the last eruptive phase, possibly extending over 1,000 years. They relate the archaeological materials to evidences from the mainland of Papua New Guinea, especially in relation to the historically known trading networks of the Madang and Vitiaz Strait areas. The third paper, by Ball, reviews the history of foreign contacts with the island, drawing upon written accounts up to the end of the war in the Pacific (1945). In the fourth paper Ball and Hughes summarise the recent human history of the island as presented in myths and legends, and describe aspects of the

islanders' life style and land use. They describe the dilemmas confronting the islanders as a result of social and economic development. The final paper is an annotated bibliography of the island prepared by Ball.

No linguist has yet worked on Long Island, though Lincoln (1976) has studied the languages spoken on the mainland opposite. None of the authors is a linguist, and we have rendered what we heard in the orthography used for New Guinea Pidgin (NGP) by Mihalic (1971: 3-8) for the Madang area dialect. We have italicised foreign words other than names which have already been borrowed into and published as English (e.g. Arop, Umboi). In many cases, the European names given on old maps have already been replaced by local names, but confusion is still possible because of historical lag and the large number of languages and dialects spoken in the area. The following are those most likely to be confused:

Early name	**English**	**New Guinea Pidgin**	**Long Island Arop language**
Long Island	Long Island or Arop	Arop	Pono
Lottin	Tolokiwa	—	Lokep
Tupinier	Sakar	—	Orenge
Rook	Umboi	Biksiasi or Siasi	Kowai (NW inland) and Siasi (SE coasts)
	Siassi Islands	Siasi	Siasi
Kaiser Wilhelmsland	New Guinea	Niugini	Kowalmai
Rich's Island	Bagabag	—	—
Dampier Island	Karkar	—	—

The names of many places, rivers and other features of the landscape have been incorrectly recorded on published maps of the island. The vernacular names used in the papers are those used by the islanders themselves; where variants of a name were recorded, we have chosen the form used by those living closest to the relevant locality.

These papers do not constitute a comprehensive history of the island and its inhabitants, but we believe that they provide a framework for the development of further research on the human utilisation of a unique island. All ecosystems are open systems, but islands have always attracted geographical and biological research workers for reasons discussed by Fosberg (1963:5). Long Island has the additional attraction of providing a starting point for the study of the processes of biological recolonization, including a rare opportunity to examine recolonization by the human species itself.

ACKNOWLEDGEMENTS

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was prepared by P. Greer. The photographs were taken by E. Ball, who also holds the original negatives.

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LONG ISLAND, PAPUA NEW GUINEA ASPECTS OF LANDFORMS AND TEPHROSTRATIGRAPHY

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SUMMARY

Present day geomorphic processes on Long Island include rapid trimming of the coastline and caldera wall by wave action. Deep, rapidly eroding linear gullies cut in the youngest pyroclastic deposits expose numerous sections which allow reconstructions of the island's recent eruptive history.

Deposits from three major Plinian and Peléan pyroclastic eruptions dated at approximately 16,000, 4,000 and 200-300 radiocarbon years bp have been recognised. These phases of cataclysmic activity, probably with associated caldera collapse, were separated by numerous intermittent tephra falls many of which would have been heavy enough to destroy much of the physical environment of the island. Interpretation of the pyroclastic deposits erupted during the period of human occupation provide information about changes in the physical environment.

INTRODUCTION

Although investigations of the volcanology of Long Island extend back to the early 1950's, attention has been focused almost entirely on present activity and petrology to the neglect of the geomorphology and the widespread tephra mantles. The investigations outlined here indicate that the tephrostratigraphy provides the key to the recent history of the central part of the island including the caldera, Lake Wisdom.

Field examination by the three authors was concentrated on the western and northern parts of Long Island. Twenty-four exposures of tephra layers were recorded in some detail and more cursory examinations were made at numerous other sites. These observations together with air photo interpretation indicate that the principal events in the evolution of the present topography of Long Island include the early development of a central volcano, the growth of major and minor satellite eruptive centres, and the occurrence of recent major eruptions which resulted in the formation of the large central caldera and the deposition of extensive and thick pyroclastic deposits. The most important elements of the geomorphology of the island are those relating to the recent phases of major eruption and caldera collapse.

In the present paper significant aspects of the island's geomorphology and the stratigraphy of the pyroclastic deposits emplaced in the Late Quaternary are described and discussed and used to provide some information about aspects of the physical environment during the period of human occupation. An appendix by Blong presents an argument for the date of the latest eruptive activity which devastated the island. An accurate dating of this event is important for the study of biological recolonization of the island.

Records of the Australian Museum, 1982, **Volume 34 Number 7**, 419–426, Figures 1–2.

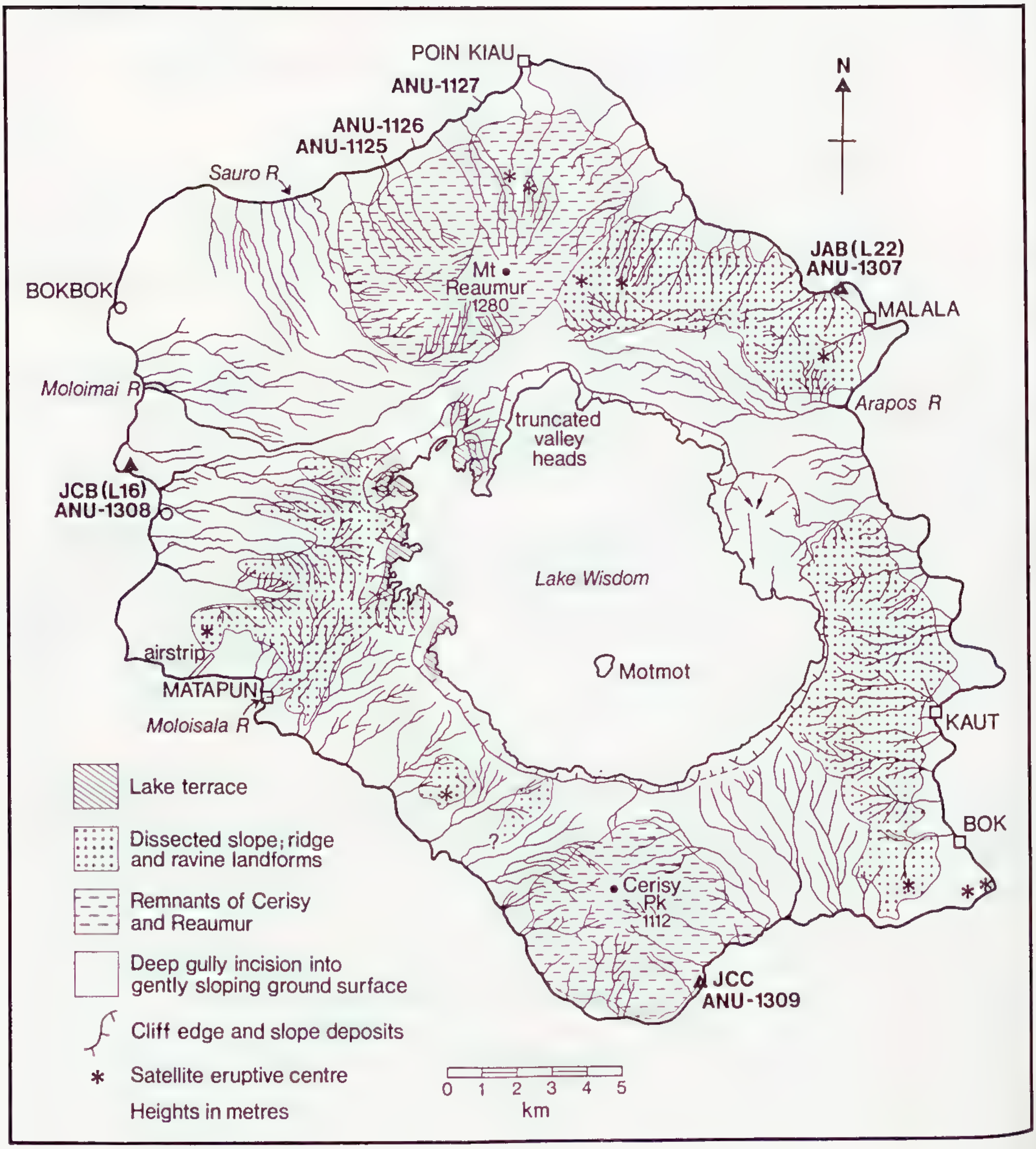

Figure 1. Map of Long Island showing major landforms.

LANDFORMS OF LONG ISLAND

Most of Long Island consists of gentle slopes radiating out from the caldera margins (Fig. 1). These slopes are dissected by numerous gullies which increase in depth inland, in some cases terminating in vertical head-walls up to 30 m high. The steep sidewalls expose unconsolidated pyroclastics and derived sediments, while the broad, normally dry, gully floors often contain a series of gravel bars and inset terraces 2-3 m high. Larger gullies (e.g. the Moloimai River) have braided beds but large scale sediment transport probably occurs on only a few days each year. In some gullies thin lava flows provide resistant bands giving the gully a stepped longitudinal profile.

Most of the coastline is formed in unconsolidated pyroclastic materials and is cliffed and undergoing active retreat due to wave action. Large trees hang precariously over the cliff edge, while cliffs and talus slopes are often notched, with new debris slopes of cliff-fall and windriven material accumulating on the upper beach. In a few places (e.g. north of Biliau and north-west of Malala) older more consolidated pyroclastics provide a more stable coastline as do the lavas outcropping at various sites (e.g. around Cerisy Peak).

Wave action is also eroding the margins of the caldera lake. Motmot, the island in Lake Wisdom, in the past has been rapidly eroded by wind and waves (Ball and Glucksman 1975) since it consisted only of unconsolidated pyroclastics, but lava flows in 1973-74 have reduced this process. To the northern side of the lake, near-vertical cliffs rise about 200 m, and several valley heads have been truncated. This contrasts with the caldera wall around the western embayment of Lake Wisdom which exhibits a well-developed stream network, the lower part of which has been drowned by the lake. The shoreline of this bay is very irregular, and bathymetric surveys by Ball and Glucksman (1978) and McKee show that it is much shallower than the rest of the caldera. A terrace is well preserved here some 10-15 m above present lake level, perhaps indicating a higher lake level. These lines of evidence suggest that the western embayment is older than the rest of the caldera and that more than one phase of caldera collapse has occurred.

On the eastern margin of the caldera a 3 km long section slopes southward and the surrounding scarp indicates that subsidence has occurred. A 400 m wide breach in the scarp allows drainage from the subsided section to the sea; another drainage system to the south leads into Lake Wisdom.

Mt Reaumur (1280 m) and Cerisy Peak (1112 m) are steepsided basaltic volcanoes dissected by radiating streams. Neither shows evidence of activity during the last few thousand years. Several other minor eruptive centres also appear to be extinct.

On morphological grounds the oldest landforms are extensive areas of ridge and ravine topography. These areas with steep slopes and high drainage densities have been so completely dissected that no remnants of the original surface remain. With the exception of a small area on the southwest margin of the caldera and a large one west of Malala these areas of rock outcrop slope generally away from the centre of the island. Field investigations north of Matapun, south and west of Malala and west of Bok indicate that erosional remnants of extinct satellite eruptive centres are present in all three main areas of this landform and that lava flows were abundantly produced by these volcanoes. On the other hand, the indented margin of this landform in the area north of Matapun suggests dissection of the flank of a volcano by radial drainage. Other rock exposures, specifically in the area west of Malala, may also represent the flanks of a central volcano but this is not firmly established.

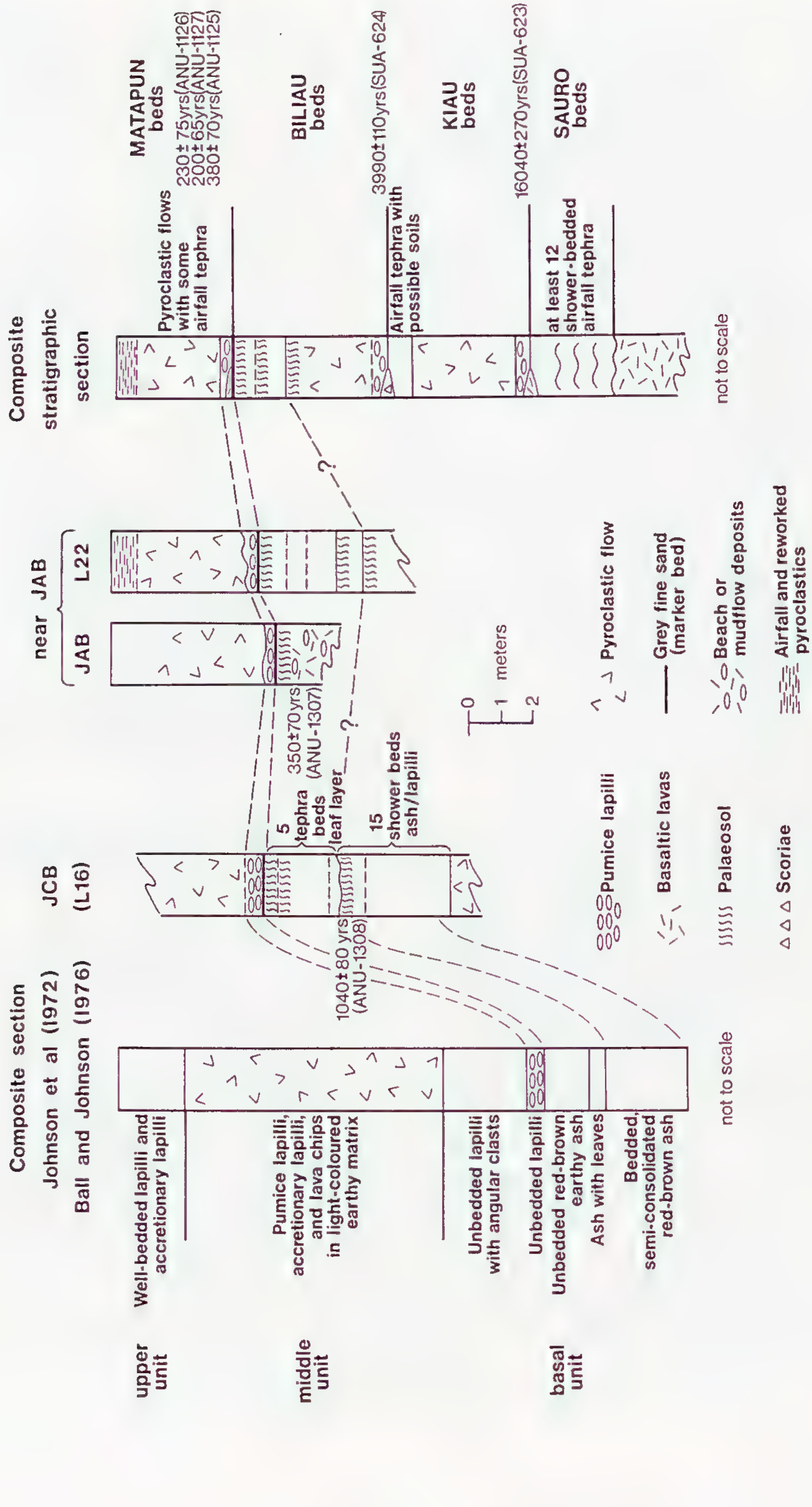

Figure 2. Tephrostratigraphy of Long Island.

TEPHROSTRATIGRAPHY AND ERUPTIVE HISTORY

This section is concerned mainly with the unconsolidated pyroclastic deposits formed during the latter part of the eruptive history of the Long Island volcanic complex. The general tephrostratigraphy, based on field observations on the western and northern sides of the island, is illustrated and compared with the earlier work of Johnson *et al*. (1972) and Ball and Johnson (1976) in Figure 2. This interpretation revises the threefold division of Johnson *et al*. (1972). Substantive details for this revision are presented in Pain *et al*. (in press). Correlations are also drawn with the stratigraphy at or near two archaeological sites, JAB and JCB.

Sauro beds: these are best exposed in the middle and upper reaches of the Sauro river valley southwest of Poin Kiau. At least twelve shower bedded airfall tephras occur.

Kiau beds: minor basaltic lava flows occur at some localities, but the Sauro beds are usually overlain by the basal lapilli member of the Kiau beds, which in turn is overlain by pyroclastic flow deposits. A series of airfall tephras with possible intervening soils completes the sequence. Charcoal from the outer rings of a tree trunk lying on the basal pumice lapilli of the Kiau beds in the headward end of Moloisala River near Matapun provides a ^{14}C age of 16,040 ± 270 years bp (SUA-623).

Biliau beds: these represent a depositional sequence identical to that of the Kiau beds. A charcoaled log from the basal lapilli of the Biliau beds exposed on the coast northwest of Malala yielded a ^{14}C age of 3990 ± 110 years bp (SUA-624).

The pyroclastic flow unit of the Biliau beds is overlain by airfall tephras with at least three palaeosols of which two are well-developed. Charcoal in the lowermost palaeosol at the JCB archaeological site gave a ^{14}C age of 1040 ± 80 years bp (ANU-1308), while a soil formed directly under the basal unit of the Matapun beds at archaeological site JAB contains charcoal dated at 350 ± 70 years bp (ANU-1307). The palaeosols and ^{14}C dates indicate that intermittent eruptive activity continued for a considerable period after the catastrophic emplacement of the pyroclastic flow unit.

Matapun beds: the base of these beds is marked by a 1-2 cm thick layer of grey fine sand overlain by up to two metres of pumice lapilli. As with the Biliau and Kiau beds, most of this sequence is composed of pyroclastic flow deposits, in some sections up to 10 m thick (equivalent to the 'middle unit' of Johnson *et al*. (1972)). In some localities several flow units can be recognised with basal sequences of gently undulating cross bedded deposits of pumice lapilli and lava fragments. Other sections contain numerous carbonised logs, oriented generally away from the caldera with a dip slightly greater than that of the present ground surface. Three samples of carbonized wood collected by Hughes from this unit have been dated 230 ± 75 years bp (ANU-1126), 200 ± 65 years bp (ANU-1127), and 380 ± 70 years bp (ANU-1125). At the top of the Matapun beds minor airfall tephras occur, often exhibiting a platy structure. Many exposures have been extensively reworked by fluvial action and mudflows.

DISCUSSION

The Matapun eruptive sequence began with the emplacement of an airfall pumice lapilli unit, continued with a series of pyroclastic flows, and concluded with the deposition of a thin, fine-grained airfall tephra. Such an eruptive sequence is similar to the classic eruptions of Vesuvius in AD 79 and Santorini in Minoan times (Lirer *et al*. 1973; Bond and Sparks 1976). As Sparks and Wilson (1976) have demonstrated, the occurrence of an initial airfall (Plinian) phase followed by the production of ignimbrites or pyroclastic flows (Peléan phase) is explained by a model involving

gravitational collapse of the eruptive column.

The Matapun ignimbrite sequence was preceded by two similar eruptive phases which emplaced the Kiau and Biliau basal lapilli and subsequent ignimbrites. These two phases were each followed by intermittent eruptive activity and soil formation.

The recognition of three periods of emplacement of massive quantities of ignimbrites suggests the possibility of three phases of caldera collapse, as it seems unlikely that large scale evacuation of the magma chamber can occur without collapse. This lends some additional credence to the geomorphic evidence for more than one phase of collapse, and to the suggestion of Ball and Johnson (1976) that the abundance of volcaniclastic materials in the lower visible part of the caldera wall may indicate a series of subsidence events.

Most of the island's coastline and more than half of the interior comprises one landform unit, the surface of which is the result of the emplacement and subsequent reworking of the Matapun beds. These created a new landsurface over the island, with the partial exception of Cerisy, Reaumur and other older remnants. Much of the exposed Matapun ignimbrites is underlain by the older Kiau and Biliau ignimbrites. Numerous exposures in present-day gullies indicate that these earlier landscapes were also dissected by a series of valleys similar to those existing today, and evidently on the same drainage lines. Although the surfaces are similar in form, the present ground surface along the coast and lower flanks of the island is 5-30 + m higher than prior to the deposition of the Matapun beds. These beds have also significantly extended the area of the island, at least on the western and northern sides; each previous ignimbrite eruption may have similarly extended the island's area, followed by rapid erosional retreat. Only in very limited areas, such as at the JCB, JCC and JAB archaeological sites and areas of lava flows around Cerisy Peak and south of Malala, do deposits older than the Matapun beds outcrop on the coast.

Archaeological sites JCB and JAB show that Long Island was inhabited, though not necessarily continuously, for possibly 700 years from about 1,000 years ago. During this time several major tephra falls occurred. At the JCB site individual tephras range up to 27 cm in compacted thickness. The initial airfall deposits could have been as much as 50 cm thick. Evidence from eruptions elsewhere for which historical documents are available indicate that tephra falls of as little as 10-15 cm uncompacted thickness are sufficient to cause the collapse of houses, the destruction of crops and forest, and the death of wild, feral and domesticated animals (Blong, in press). Thus, even intermittent tephra falls between the ignimbrite eruptions could have destroyed much if not all of the biota of Long Island. Its inhabitants, therefore, may have been forced to evacuate the island on several occasions. During the ignimbrite eruptions the destruction of life and habitat would have been virtually complete, not only because of the high temperatures of the ignimbrites, but also because of the thickness of the new deposits.

Recognition that the same eruptive sequence of ignimbrite eruptions, followed by intermittent tephra falls, has occurred three times since the older volcanoes of Cerisy and Reaumur ceased activity, suggests that the Long Island centre will continue with limited intermittent activity involving mainly tephra falls with long intervals of soil formation before again entering a phase of cataclysmic (Plinian and Peléan) activity.

APPENDIX 1: (R. J. Blong)

The three radiocarbon dates on the Matapun beds (ANU-1125, ANU-1126, and ANU-1127) are expressed, as are all radiocarbon dates, in terms of radiocarbon years.

Such recent dates, however, require correction before they can be expressed in calendar years.

The pooled mean of the three dates can be obtained using the expression.

$$PM(3) = \frac{Ab^2c^2 + Ba^2c^2 + Ca^2b^2}{a^2b^2 + b^2c^2 + a^2c^2} \pm \left(\frac{a^2b^2c^2}{a^2b^2 + b^2c^2 + a^2c^2}\right)^{1/2}$$

where A ± a, B ± b, and C ± c represent the three radiometric ages (Polach, 1976).

In the present case A ± a = 380 ± 70
B ± b = 230 ± 75
C ± c = 200 ± 65

Substituting in the above equation the pooled mean of the three dates become 270 ± 40. This single estimate can now be converted from radiocarbon years to calendar years using calibrations derived from tree ring corrections. For the present exercise the following curves and corrections were used:

		Year AD
Damon, Long and Wallick (1972):	270 ± 40 becomes 305 ± 66	= 1580-1710
Ralph, Michael and Han (1973):	340-420 yrs BP	= 1530-1610
Clark (1975):	300-380 yrs BP	= 1570-1650
Stuiver (1978):	270-350 yrs BP	= 1600-1680

The midpoints of the estimates derived from the four calibration curves are respectively 1645, 1570, 1610, and 1640. On the basis of these age estimates we can state with some confidence that the last catastrophic eruption of Long Island and the emplacement of the Matapun beds occurred during the first half of the 17th century. A more detailed analysis by Blong (in prep.) rejects ANU -1125 on the grounds that the age estimate is substantially older than those provided by ANU -1126 and ANU -1127, pools the data with other ^{14}C dates from other sources and concludes that the radiocarbon evidence indicates that the eruption occurred between 1630 and 1670 A.D. The arguments presented have been summarised in Pain *et al.* (in press).

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LONG ISLAND, PAPUA NEW GUINEA — ASPECTS OF THE PREHISTORY

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SUMMARY

Five archaeological sites are described from the present-day coast of Long Island, and their probable ages are discussed. The earliest human occupation was at least 1000 years ago, with further occupation between about 350-550 years ago. Obsidian was imported from Talasea, New Britain, and possibly several kinds of pottery may have been imported from the mainland of New Guinea. The relation of Long Island to historically-known trading networks is discussed.

INTRODUCTION

Long Island, in the Madang Province of Papua New Guinea, stands at the northern end of Vitiaz Strait, about 50 km from the New Guinea mainland. Although administratively placed within the Madang Province, the island is culturally, as well as geographically, intermediate between the Madang-Rai coast areas and the communities of Vitiaz and Dampier Straits. Studies of their oral history and mythology (Ball and Hughes 1982) reveal that the islanders have a recent history which reflects this position. However, their main external contacts during the period of white contact appear to have been with the peoples of the Vitiaz Strait, with the island standing at the westerly limit of the Vitiaz Strait exchange network (Harding 1967); the island appears to have been by-passed by traders operating from the Madang area.

Our interest in Long Island arose from our archaeological and ethnographic studies in the Madang (Egloff) and Huon Peninsula (Specht) areas. With Long Island standing, as it were, at the interface between our research areas, we decided to visit the island in 1973 to examine several archaeological sites reported by earlier visitors. Finds from these sites suggested that they might pre-date the last major eruptive phase to devastate the island, and thus might provide information on Long Island's position in the exchange networks of our respective research areas prior to the period of European contact.

THE ARCHAEOLOGICAL SITES

Five archaeological sites are known from Long Island (Fig. 2) but, with the exception of brief notices by Bassot and Ball (1972: 27), Johnson *et al.* (1972: 48), and Egloff (1975: 14), no details of these sites have been published. The first site to be recorded, JCT, was reported to Specht in 1969 by J. S. Womersley, formerly of the Botanic Gardens, Lae; this site has not been visited by the authors. The second site, JAB, was recorded in 1970 by J. Wood, then with Gem Exploration and Mining Pty. Ltd. In 1972 Hughes collected at this site and visited two others, JCB and JCC. The fifth site, JCW, was visited by R. Blong, C. Pain and C. McKee in 1976, but no artefacts were collected. In 1973 Specht and Egloff visited JAB, JCB and JCC with Hughes, and each site was visited by Ball on subsequent occasions. This paper is based mainly on data recovered in 1973, with additional information and artefacts from other visits included

Records of the Australian Museum, 1982, **Volume 34 Number 8**, 427–446, Figures 1–7.

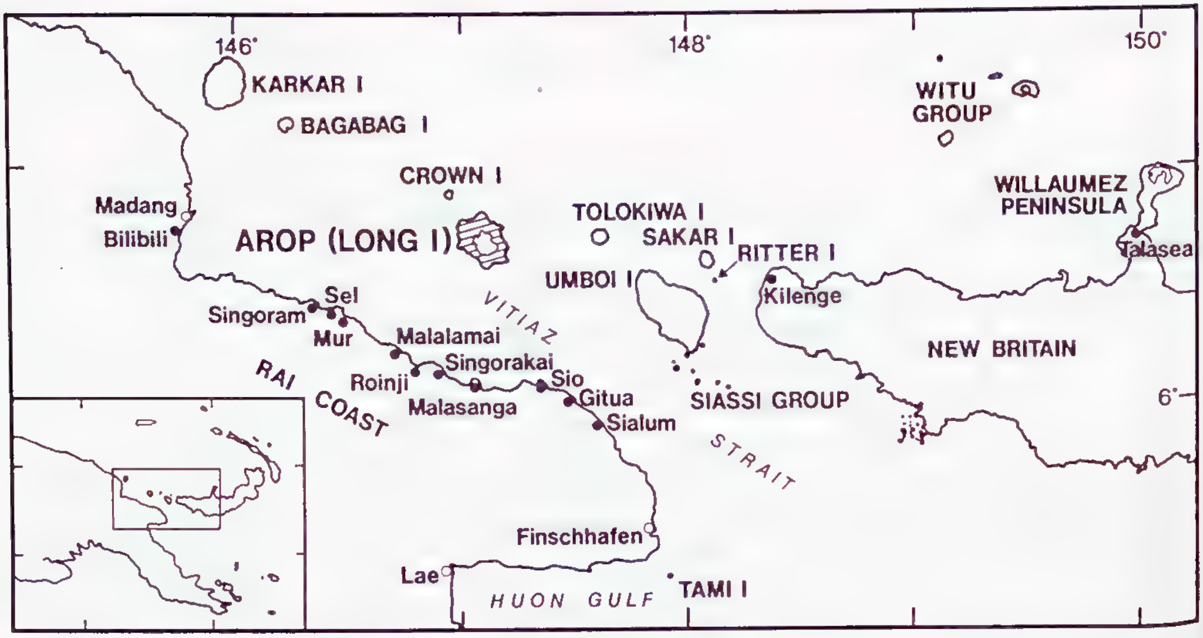


Fig. 1. Long Island in relation to New Guinea and the adjacent islands.

where relevant. The artefacts described here have been deposited in the National Museum and Art Gallery, Waigani, Papua New Guinea.

All of the sites are beach front exposures revealed by marine erosion of the pyroclastic mantle by wave action. This erosion is a continuing process, so that during the six years over which the three main sites (JAB, JCB, JCC) have been visited and collections made from them, each site has presented a slightly different exposure to the various investigators and presumably has decreased in size in the horizontal plane. Therefore, no two collections at any one site have necessarily come from the same position within the site. At one site, JAB, the exposure studied by Hughes in 1972 was totally concealed by cliff fall in 1973, when observations were made at a different though nearby locality which is presumed to be part of the same stratigraphic horizon, though this cannot be demonstrated. For the purposes of this paper, the various collections at each site are distinguished according to their collectors.

Archaeological surveying has not been conducted in the island's interior, where sites earlier than deposits of the last eruptive phase, the Matapun beds, may be revealed by erosional channels cutting through the pyroclastic mantle. The current inhabitants of Long Island have reported several other former settlement sites on the coast which we have not visited, but are unaware of any in the island's interior.

None of the sites described here has been excavated. In 1973, time permitted only the recording of the sites and collection of samples of cultural materials eroding from them, including organic material for ^{14}C dating. Only limited stratigraphic analysis was possible in the field, but subsequent discussions with Ball, Blong and Pain have clarified the relationships of the archaeological horizons to the various pyroclastic deposits.

JCB: Biliau: This site is on the west coast near the settlement of Biliau. Here the cliff rises to a maximum of about ten metres above the beach, with sherds and obsidian flakes eroding in small quantities at about 70 cm above the present beach level. In 1973 artefacts were collected at two points, A and B, in the cliff face about 40 metres apart, and from the beach surface below and between these points. In 1976

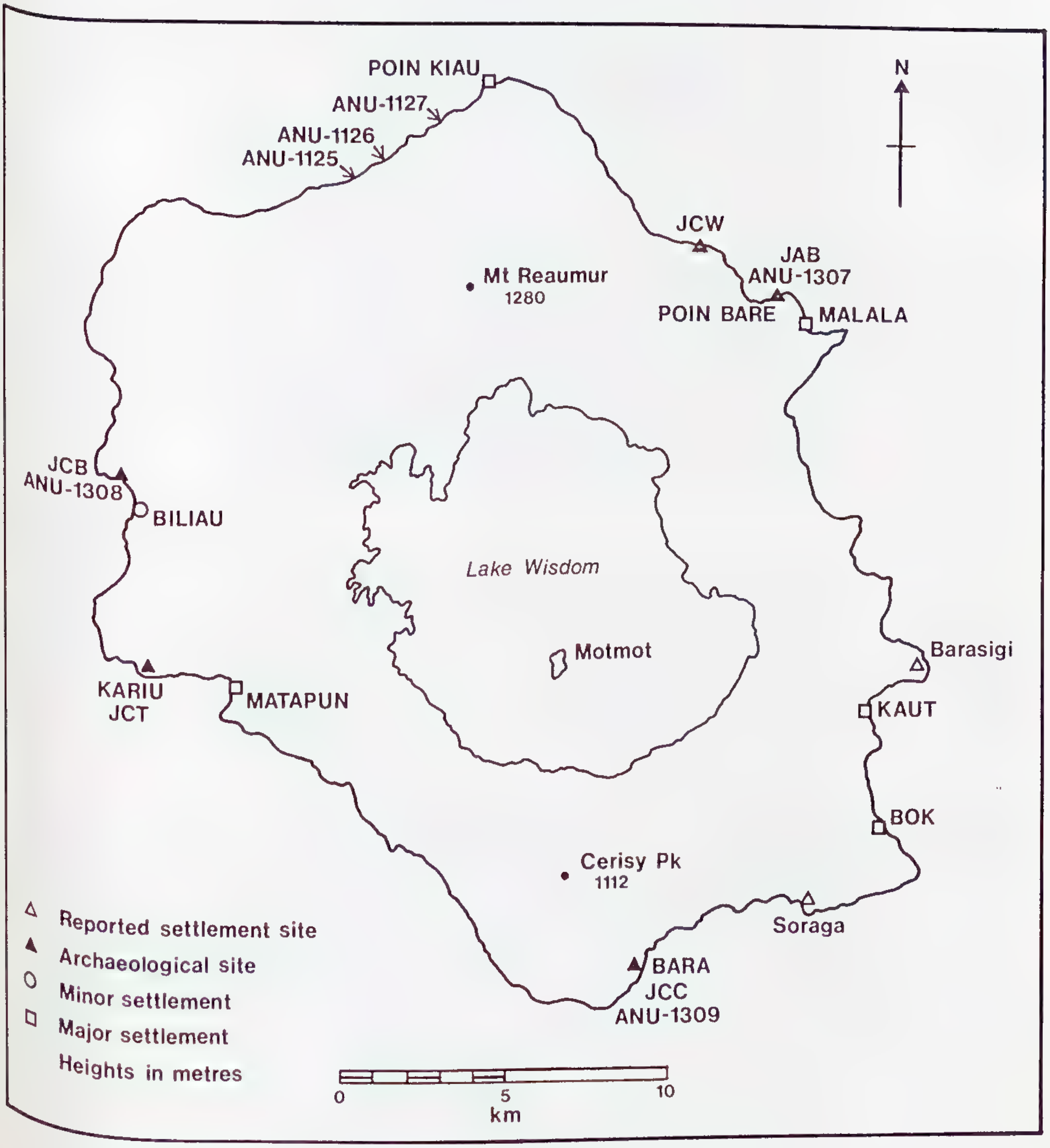


Fig. 2. Long Island: location of prehistoric sites.

Blong, Pain and McKee also collected at this site, but the position of their collection locality relative to points A and B is not clear. They recovered sherds and an obsidian flake from the top of the oldest of three palaeosols in the upper section of the Biliau beds, beneath what they term 'leaf ash'. Our 1973 collection at point B of sherds and obsidian flakes came from immediately above and below a thin deposit of pumice lapilli. This lens shaped deposit was not noted by Blong, Pain and McKee, and its significance is not clear; it could indicate two phases of occupation or reworking of the deposit, though Blong and Pain suggest that reworking is unlikely. The 1973 collection probably came from one of the three palaeosols in the upper section of the Biliau beds, possibly the youngest one. At this stage it is assumed that point A also relates to one of these palaeosols.

Charcoal collected at point A yielded a radiocarbon age of 1040 years ± 80 bp (ANU-1308) (see Appendix I). This sample may refer to the age of the single sherd found here or to the age of the palaeosol. This sherd has also been dated by the thermoluminescence technique to 'greater than 360 years' (Appendix I). Five sherds from point B have also been dated by this technique; four from above the pumice lapilli gave ages of 390, 410, 200-460 and 'greater than 260 years' (Appendix I), and one sherd from below the pumice lapilli has an age of 'several hundred years'. The apparent discrepancy between the radiocarbon and thermoluminescence ages will be discussed below.

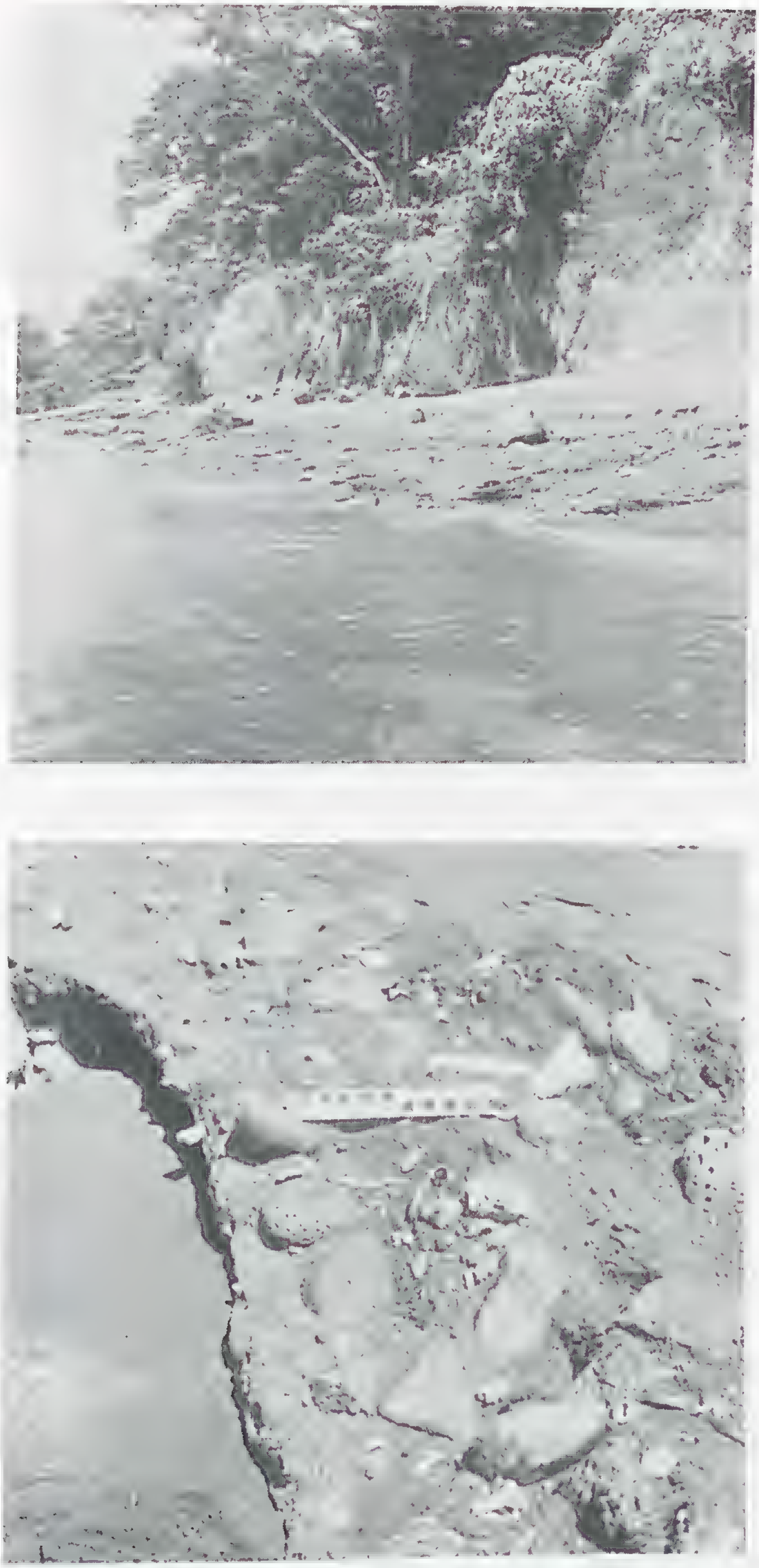
JCC: Bara: This is an exposure near the base of a low cliff at the southern end of the island. Fragments of marine molluscs, bones, pottery and obsidian were found in a red-brown mud-flow deposit together with coarse rounded to sub-angular gravels. The mud-flow is a pre-Matapun beds deposit inset into the top of the Biliau beds. This identification of the stratigraphic position was made by Blong and Pain from photographs and fieldnotes recorded by Ball in 1978. A radiocarbon sample collected in 1973 gave an age of 470 years ± 240 bp (ANU-1309). Since the deposit is now recognised as a mud-flow deposit, and thus may incorporate charcoal from events widely separated in time, it is impossible to identify what the sample is actually dating; this date will not be considered further.

JAB: Poin Bare: This site is on the east coast to the north of Malala village. J. Wood, who reported the site in 1970, observed human bones eroding from the cliff base, an observation also made by people of Malala village. In 1972 Hughes collected sherds from the cliff base, just above high tide level, point A, but did not see bones. This point was concealed by cliff fall in 1973 and could not be re-examined then. About 50 metres to the north in 1973 an artefact-bearing deposit exposed by wave action, point B, was examined (Fig. 3). This is a pre-Matapun beds deposit. Its relationship to point A cannot be established now. Blong, Pain and McKee suggest that these deposits may relate to a palaeosol of the Biliau beds, possibly the uppermost one.

Charcoal collected in 1973 at two points several metres apart at point B has a radiocarbon age of 350 years ± 70 B.P. (ANU-1307). This charcoal came from the layer containing marine molluscs, bones, sherds and obsidian flakes.

JCT: Kariu Point: According to J. Womersley (pers. comm.), this site is on Kariu Point just north of Matapun village. Womersley reported bones, shell and sherds eroding from near the cliff base.

JCW: Patauru: This site was recorded by Blong, Pain and McKee in 1976 as a cliff-face exposure near beach level about 2.5 km north from site JAB. They did not collect at the site, but observed sherds. The deposit is apparently an upper level of the Biliau beds.



a

b

Fig. 3. Long Island: (a) general view of site JAB/B, (b) cultural materials eroding from beach deposits at JAB/B.

CULTURAL MATERIAL COLLECTED

Fragments of marine molluscs were collected at JAB/B and at JCC. The following identifications and comments were provided by P. Swadling, National Museum of Papua New Guinea:

JAB/B: one half valve of *Tridacna crocea,* young specimen.

JCC: one gastropod whorl fragment, possibly *Turbo crassus;* one whorl fragment of a coral reef gastropod, possibly of the family Muricidae.

The Womersley collection from JCT includes one bivalve fragment, possibly *Tridacna crocea.*

T. crocea and the Muricidae are coral reef dwellers; fringing reefs are present at many points around the island. *T. crassus* prefers a fairly exposed rocky shore; such conditions are present today on the south coast near site JCC.

Bone fragments have been identified by J. I. Menzies, Department of Biology, University of Papua New Guinea:

JAB/B: pig — three fragments of a third molar, fragments of the distal end of a fibula, and four long bone fragments which might be pig.
human — one possible proximal end fragment of a radius.

JCC: human — two fragments which may be from a radius and an ulna.

In 1978 Ball collected fragments of a pig molar and an unidentified long bone at the site JCC.

Sherds and obsidian flakes were the only artefacts found at the sites; none of the molluscan remains appear to have been utilised, though their poor state of preservation may conceal evidence for use.

Small chips of obsidian have been found at three sites: none of these has been secondarily worked, though several display what might be usewear along thin edges. They are all small, with a length range of 11-28 mm and weight range of 0.1-1.2 grams. Their site distribution is shown on Table 1.

TABLE 1.

Obsidian from Long Island sites

JAB		JCB		JCC	
point A	0	point A	1	1973	10
point B	2	point B	2	Ball	8
Blong *et al.*	10	Ball	3		
		Blong *et al.*	1		
Totals	12		7		18

Trace element analysis using atomic absorption conducted by W. Ambrose, Department of Prehistory, Australian National University, shows one sample (No. 206) from JCB/B to be indistinguishable from the Talasea source on New Britain. Samples 207 and 208 from JCB/B and 209 and 210 from JCC have density values which fall within the Talasea range.

A total of 144 sherds has been found since 1969; their distribution is shown on Table 2. Five clay bodies are apparent from hand specimens examined under a 10 x

hand lens. The integrity of these identifications has not been tested by petrographic or other compositional analysis, and some modification may be necessary when this is carried out. Since it is not known whether tempers were deliberately added, the term 'inclusion' is used here for the distinctive constituents of each clay body.

Clay A varies in colour from dark grey to light brown, probably reflecting differing firing conditions and post-firing histories. The sherds contain fine white or translucent inclusions up to 1 mm long; grey, red and red-brown inclusions up to 1.5 mm long; and small rock fragments up to 2 mm in length. Sherd thickness ranges between 2.5 to 8 mm, with a mean of 5.2 mm.

Clay B resembles clay A, but also contains variable amounts of shiny black, flat angular inclusions 1 mm or less in length, and lacks the red and red-brown inclusions. The single sherd of clay B from JCB/A contains hornblende and a significant quantity of magnetite, and possibly pyroxene and plagioclase (F. L. Sutherland, pers. comm.). The sherds have a thickness range of 3 to 9 mm, with a mean of 6.1 mm.

Clay C is represented by one sherd only, from the beach in front of JCB. It is made from a fine clay without visible inclusions, which has formed hard, chunky plates during firing. The surfaces are dark red-brown, with a dark grey to black core. Its thickness is 6-8 mm.

Clay D is tentatively identified from one sherd from JCB/C and one from JAB. It has a gritty texture of blue-grey colour, lacking the inclusions typical of clay A; macroscopically it does not resemble the other clays. Their thicknesses are 7 mm and 8 mm.

Clay E is represented by a group of sherds collected by Hughes at JAB/A in 1972. Their similarity as a group is such that they probably represent one or two vessels only. In colour they are purple-brown throughout, very hard and with a gritty texture. The inclusions are translucent or black, up to 1.5 mm in length. Thickness ranges between 5 and 19 mm, with a mean of 12.1 mm. These sherds differ markedly in appearance from the others, and may have been subjected to greater heat during firing or in a volcanic eruption.

Most sherds are too small to determine construction techniques, and generally surface treatments have obliterated any indications which may once have existed. Only the paddle and anvil finishing technique can be identified with certainty. The sherd of clay C is splitting along its longitudinal axis, possibly indicating an additive technique of construction, or perhaps reflecting qualities inherent in the clay.

The only vessel form recognised is a round-bodied vessel with an incurving upper body and everted or vertical rim; some sherds display an angled shoulder. The latter is found only on sherds of clay E at JAB/A and on one sherd of clay A from JCB. The round-bodied form also occurs in Clay B. Eight rim profiles are recognised (Fig. 4), though several of these (e.g. profiles 1 and 2) could be fragments of others (e.g. profiles 3 and 4).

Several sherds of clays A and B appear to be coated with a red to red-brown pigment, possibly a slip; on the clay B sherd from JCB/A the pigment extends over the lip on to the rim interior, and on the exterior of a clay A sherd from JCT the pigment ends abruptly in a straight line as though it had been painted on to the vessel. Occasionally the pigment covers various kinds of decoration.

Decorative techniques include linear incision, applied relief, and short slashes or punctations. Applied relief varies from prominent to very narrow, low bands; on occasions the latter are so indistinct that they may not be applied but the result of

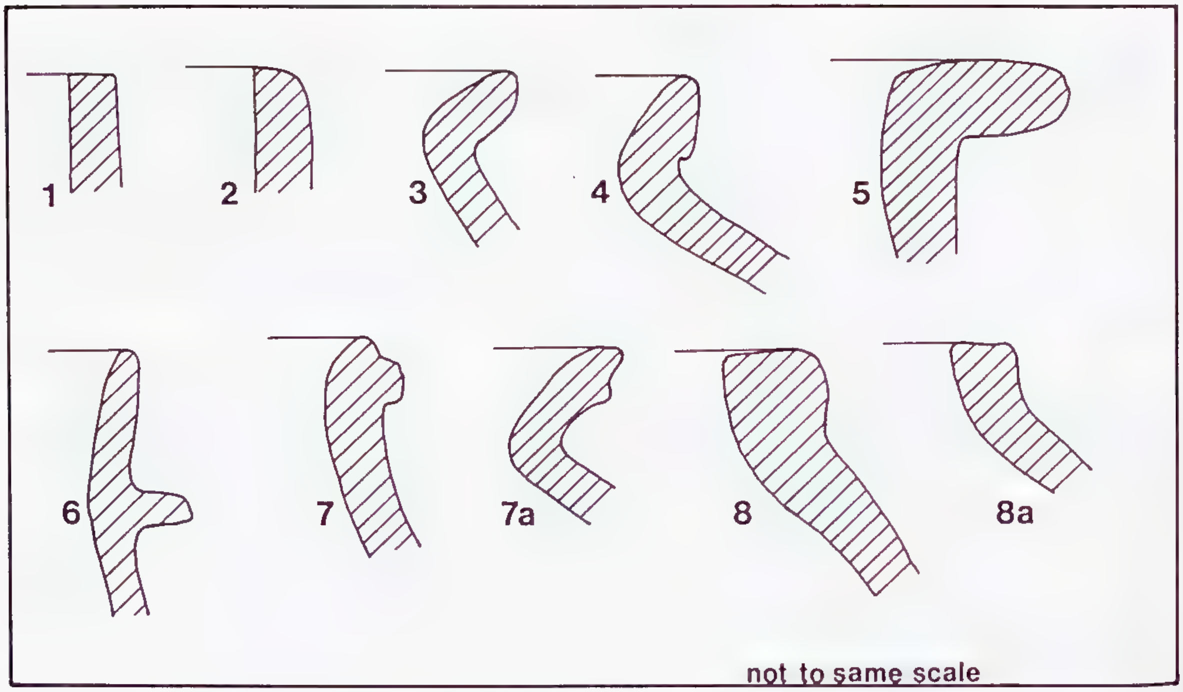


Fig. 4. Long Island: rim profiles of prehistoric sherds.

finger-trailing over wet clay. The prominent bands are often notched. No sherd combines applied relief and linear incision. Designs are mostly simple, arranged around the neck and upper body (Figs 5, 6). The clay B sherd from JCB/A has incised lines on the rim interior.

Notching is common on the interior and exterior angles of the lip, and occasionally on the interior angle of the rim. The external flanges of profiles 6 and 7 are also notched. The notching is broad and smoothly curving, or narrow and sharp.

Tables 2 to 5 summarize the associations of clay group, rim profiles and decorative techniques for the four sites.

TABLE 2. **Distribution of clay groups at Long Island sites.**

Group	JAB/A	JAB/B	JCB	JCB/A	JCC	JCT	Totals
A	—	18	58	—	29	4	109
B	1	2	6	1	2	—	12
C	—	—	1	—	—	—	1
D	—	—	2	—	—	—	2
E	20	—	—	—	—	—	20
Totals	21	20	67	1	31	4	144

Note: The figures for JAB/B, JCB, and JCC combine collections made over several years by Ball, Hughes, Egloff and Specht, and Blong, Pain and McKee.

TABLE 3. **Distribution of diagnostic sherds.**

	JAB	JCB	JCC	JCT	Totals
Rim	5	7	3	1	16
Decorated body	12	17	—	1	30
Totals	17	24	3	2	46

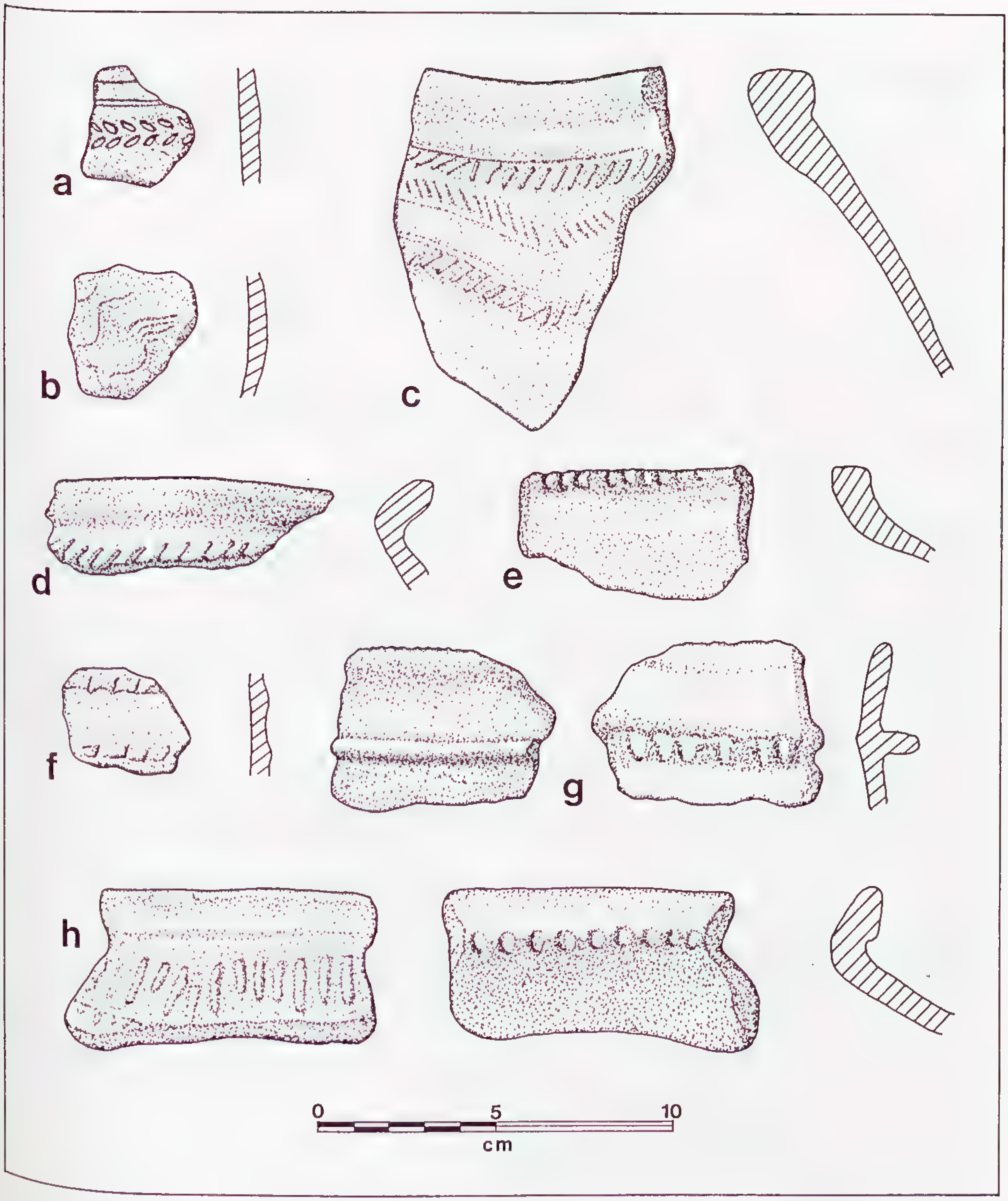


Fig. 5. Long Island: decorated and rim sherds from prehistoric sites. (a) JAB/B, clay A, incised and punctate. (b) JAB, clay A, incised. (c) JCC, clay A, relief. (d) JAB, clay A, relief. (e) JCC, clay A, notched interior lip. (f) JCB/B, clay A, relief. (g) JCB, clay A, exterior rim flange, interior notching. (h) JCB, clay A, relief, Interior notching.

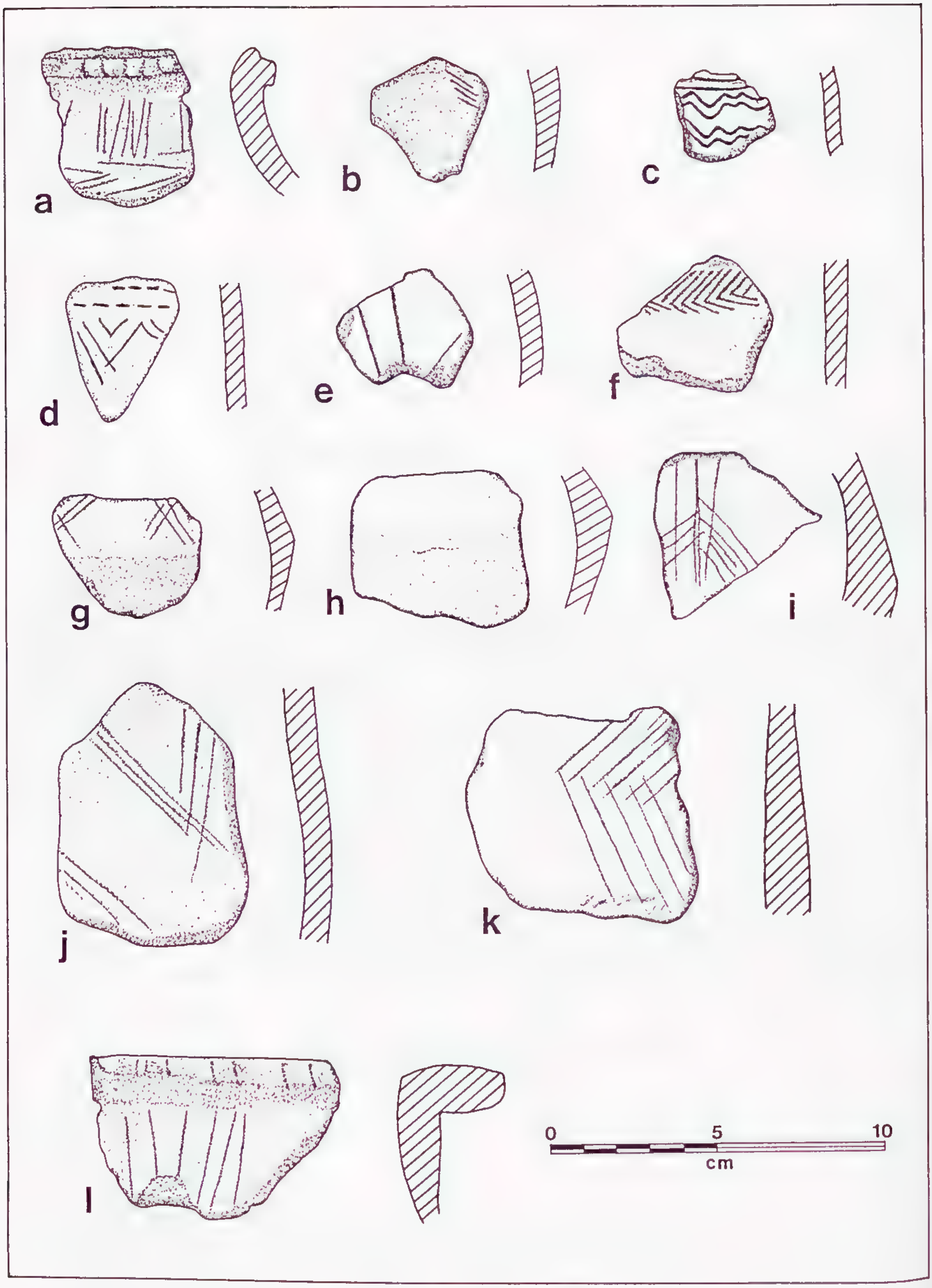


Fig. 6. Long Island: decorated and rim sherds from prehistoric sites. (a) JCB/A, clay B, incised and notched decorations, thermoluminescence sample No. 1027. (b) JCB, clay B, incised. (c) JCB, clay B, incised. (d) JCB, clay B, incised. (e) JCB, clay C, incised. (f) JCB, clay D, incised. (g) JAB/A, clay E, incised. (h) JAB/A, clay E. plain. (i) JAB/A, clay E. incised. (j) JAB/A, clay E, incised. (k) JAB/A, clay E, incised. (l) JAB/A, clay E, incised.

TABLE 4. **Distribution of rim profiles by clay group.**

Rim Profile	JAB	JCB	JCC	JCT	Totals
1	A,B	—	A	—	3
2	—	A	—	—	1
3	B,E	A(2)	—	—	4
4	E	A	—	—	2
5	—	A	—	—	1
6	—	A	—	—	1
7	—	B	—	—	1
8	—	—	A(2)	—	2
Totals	5	7	3	1	16

TABLE 5. **Distribution of decorative techniques by clay group.**

	JAB	JCB	JCC	JCT
incised	A,B,E	A,B,C,D,	—	—
relief	B	A	A	—
pigmented	B	A,B	A	A

Note: the incised category includes short slash strokes.

The small sample sizes limit the comparisons which can be made between the sites. As might be expected, the largest sample, from JCB, shows the greatest variety of attributes, yet each of the other sites have attributes unique to them individually. The scarcity of sherds of clays C and D at JCB, where one sherd each came from the beach, compared with the higher frequency of clays A and B, is possibly a reasonable picture of the relative frequency of the four groups, though frequency comparisons would be better based on vessel numbers rather than sherd counts. On the other hand, red pigment does not appear to occur with linear incision at any of the sites, and may indicate a real stylistic difference. A tentative stylistic grouping of the sherds is offered below.

The largest group includes sherds of clays A and B, from vessels finished by the paddle and anvil technique, with the following characteristics: rim profiles 1, 3 and 4; notching on the lip or rim interior; relief decoration, occasionally notched and covered by or applied with a red pigment; linear incision without pigment. These sherds form style group I.

The collection from JAB/A in clay E forms group II, currently not represented at the other sites. It has rim profiles 3 and 4, only linear incision decoration, and is generally thicker than the other style groups.

The single clay C sherd constitutes style group III which can be only sketchily delineated from this one sherd. Its identity with sherds from sites on the Huon Peninsula, between Sio and Tami Island, allows greater precision. The distinctive characteristics of this style group in the Long Island context are the clay group, hardness and smooth red-brown surfaces. On the Huon Peninsula this style has a wide range of thickened and everted rims, with rectilinear incised body decoration.

The clay B sherd from JCB/A and the two clay B rims collected by Blong, Pain and McKee from 'below leaf ash' at JCB are provisionally placed into style group IV, since their external flanges are not shared by any other style group. Group IV is further characterised by its rim profiles — profiles 7 and 8.

Many decorated body sherds, especially incised sherds, cannot be allocated with

certainty to any specific group, though some may belong to style groups I or II.

The relative and absolute datings of these style groups are not clear. Some group I sherds definitely come from levels dated to about 350 years ago (ANU-1307) at JAB/B; style group II sherds at the same site are thought to come from a comparable level. The single sherd of style group III from JÇB is unstratified and cannot be referred to any age determination from Long Island.

The three style group sherds may be as old as 1000-1100 years. The sherd from JCB/A came from a lvel dated to 1040 years ± 80 B.P. (ANU-1308), though it is not certain that this date actually refers to the age of the sherd rather than to the age of its surrounding matrix. The other two sherds are assigned by Blong, Pain and McKee (pers. comm.) to the oldest of three palaeosols in the Biliau beds at JCB; by extrapolation in stylistic terms, this palaeosol may be of the same or similar age as the JCB/A deposit. This does not necessarily conflict with the dating attributed to style groups I and II, since at JCB sherds of these styles were found in the latest of the three palaeosols and hence should be younger than style group IV. The thermoluminescence date for the group IV sherd from JCB/A is greater than 360 years, at least as old as, if not older, than the groups I and II sherds from JCB/B dated by this technique.

Further indications of the ages of the style groups can be inferred from comparisons with archaeological sites on the mainland of New Guinea. None of the Long Island sherds resemble the recent coiled pottery of the Gogol River area inland from Madang (Biro 1901), but some can be compared with contemporary and prehistoric pottery from the coastal areas of Madang and the Huon Peninsula.

The contemporary pottery of Bilibili — Yabob, just south of Madang, has various sand tempers, including a black volcanic sand, and is finished by beating with a paddle and anvil (Tuckson 1966: 13; Egloff 1975: 12). Although no stylistic study of vessel forms, rim profiles and decoration of the modern industries has been published, Allen (1971) and Egloff (1975) have described archaeological sherds from sites in the Madang area which they identify as being directly ancestral to the modern pottery. They characterise this ancestral pottery as having globular/spherical vessel forms with everted or direct rims; incised, punctate and various relief decorations; commonly a red slip; carved paddle impressions; and a range of rim profiles. The red slip is often thick, and frequently extends on to the rim interior surface (Allen 1971:3; Egloff 1975: 3). Some relief designs appear to be 'heavy blobs' of slip (Egloff 1975: 3) and formed from thick slip 'apparently painted onto the already slipped surface' (Allen 1971: 4). Incised sherds, however, are less often slipped than sherds with other decorative techniques (Egloff 1975: 10). Some rims are notched on the interior angle of the neck (Allen 1971: 3; Egloff 1975: 9), though this, and relief decoration are absent from the modern pottery. At the JCA site near Madang this ancestral pottery is at least 550 years old (Egloff 1975: 14).

This ancestral Madang pottery is identical to style group I on Long Island, though carved paddle impressions are not present in style group I and, as might be expected with a small sample, the range of designs is more limited than in the Madang area.

On Karkar Island Egloff found a different, distinctive prehistoric pottery which he has named the 'Sarong Style' (Egloff 1975). This has not been identified on Long Island. Conversely, the Long Island style groups II, III, IV have not been reported from the Madang-Karkar areas.

Surface collections and test trenches at archaeological sites on the coast of the Huon Peninsula between Wasu and Finschhafen and on Tami Island have yielded sherds similar or identical to all four Long Island groups. Sherds of style groups I and

III have been found in a test trench at site KBP on Sigawa Island, Sio, where a wood charcoal radio-carbon date of 360 years ± 100 bp (NSW-86) has been obtained. The significance of this date is open to question, since the deposit appears to have suffered post-depositional disturbance (Specht, unpublished fieldnotes). Abramson (1969: Plates IA-b, f and IB-e) reports this group from Tami Island in an undated context. Style group III occurs at several sites at Sio, Sialum and Finschhafen (Specht, unpublished fieldnotes) and on Tami Island (Abramson 1969: Plate IB-i). At Sio, in addition to occurring in the KBP site, style group III sherds are found in the mainland site of KBQ, for which a wood charcoal radiocarbon date of 800 years ± 100 bp (NSW 87) has been obtained. At the Sio sites, the style group III sherds occur with sherds of other styles, but at several sites at Sialum and Finschhafen style group III is the only pottery present. The significance of these distributions is currently not known.

The occurrence of style groups II and IV on the Huon Peninsula coast is less certain. One unstratified sherd from Sialum resembles group IV, and several sherds on the Abramson collection from Tami Island are similar to group II. In both cases these comparisons must be treated with caution.

Most of the archaeological pottery from the northern Huon Peninsula coast seems to relate to the history of the modern pottery industries of Sio and Gitua (Groves 1934; Harding 1967; Specht, in prep). Several incised sherds and notched rims from Long Island, especially in clay B, resemble this ancestral Sio/Gitua pottery, Curvilinear incised designs comparable with that shown on Figure 6c from JCB can be closely compared with sherds made from a clay similar to clay B from the KBQ site at Sio. Curvilinear incision of this kind is absent from the modern Sio/Gitua industries, which are made from calcareous clays as yet unrepresented in the Long Island collections.

These external relationships of the Long Island style groups can be summarised as follows:

(a) style group I belongs to a late prehistoric style which is ancestral to the modern industries of the Madang area. This style is widely distributed along the north coast of New Guinea to Tami Island. On the mainland this style is at least 550 years old.

(b) style group II may occur on Tami Island, but has not been recognised at sites on the mainland. On Long Island its presumed stratigraphic position places it at about 360 years ago.

(c) style group III does not occur in the Madang area, but is found from Long Island, through Sio, southwards to Tami Island. Its age is uncertain, but at the KBQ site at Sio it is at least 800 years old.

(d) style group IV is poorly known on Long Island, where it may be 1000-1100 years old. On the mainland of New Guinea it is apparently absent from the Madang area, but may occur at Sialum.

(e) some of the ungrouped incised sherds, and some notched rims from Long Island resemble sherds ancestral to the modern pottery of Sio, dated at the KBQ site to about 800 years ago. Modern Sio pottery has not been identified with certainty on Long Island.

GENERAL DISCUSSION

The first evidence for human occupation of Long Island is thus about 1000 years ago, but the recognition by Blong, Pain and McKee (1982) of a palaeosol dated about 4000 years ago indicates that habitation may have been possible at an earlier date.

Between 350 and 550 years ago there were at least five settlements on what is now the coast. If our interpretation of the stratigraphy at site JCB is correct, this site was occupied twice during periods of soil formation. These occupations were separated by a period of volcanic activity which deposited airfall tephras; these may have prevented continuous occupation of the site, and possibly of other parts of the island. The later occupation of JCB and the occupations of JAB, JCW and possibly also JCC appear to have ended just prior to the emplacement of the Matapun beds during the last major eruptive phase of the island. Charred wood and charcoal collected by Hughes from coastal exposures of the Matapun beds in the northwest have yielded radiocarbon ages of 380 years ± 70 bp (ANU-1125), 230 years ± 75 bp (ANU-1126), and 200 years ± 65 bp (ANU-1127), supporting the date obtained for the occupation of JAB. The emplacement of the first deposits of the Matapun beds may have destroyed the JAB settlement, for both J. Wood and Malala villagers saw human remains eroding from the JAB area, though these bones could have come from burials of a slightly earlier age.

The few molluscan remains from the Long Island sites are compatible with the exploitation of locally available species. Obsidian, on the other hand, was obtained from the Talasea area of New Britain, some 350 km to the east. At this stage it is impossible to determine with certainty whether any of the Long Island pottery was actually made on the island. According to Blong and Pain (pers. comm.), clays suitable for pottery manufacture may have been available on Long Island prior to the emplacement of the Matapun beds, possibly associated with deposits of the Sauro beds. However, neither the islanders nor any of the investigators have observed suitable deposits. The stylistic identity of style groups I and III with mainland prehistoric pottery suggests that pottery of these groups at least may have been imported to Long Island. A recent study of oral traditions of the Madang area indicates that the distribution of pottery making centres in the past may not have been the same as today (Mennis 1978). These oral traditions describe the existence in the past of an island called Yomba westwards from Long Island. The Yomba islanders are said to have made pottery prior to their escape to the mainland at the time that Yomba erupted. Mennis (1978) argues that the destruction of Yomba took place before the last major eruption of Long Island; her estimate is not too early for some of the Long Island pottery to have originated from Yomba.

Long Island lies between the historically-known trading networks which operated from the Madang and Vitiaz Strait areas. None of the early written accounts of the Madang network appears to include Long Island, but the island certainly received goods from the Vitiaz Strait. The islanders were visited by Siassi Islanders seeking hand drums, dogs, tobacco and other goods (Harding 1967: 18, 33, 133-4), and themselves occasionally visited the Sio villages (Vogel-Hamberg 1911: 260; Harding 1967: 23, 134). The presence of Talasea obsidian on Long Island suggests that these contacts may be of long standing. Blong, Pain and McKee found an obsidian flake at JCB in the earliest of the three palaeosols of the Biliau beds, for which an age of about 1000 years has been proposed above, while undoubted Talasea obsidian is associated at the same site with sherds of style group I dated about 350-550 years ago. An age of about 1000 years is reasonable, since Talasea obsidian was present at the KBQ site at Sio by 800 years ago, and has been transported widely throughout Melanesia for over 3000 years (Ambrose 1976a). However, this does not mean that the Vitiaz Strait trading network existed in its present form at that time; indeed, Harding (1967: 10-11, 18, 185ff) specifically notes changes in trading patterns of the Madang, Vitiaz Strait and Tami Island networks, especially since the arrival of Europeans.

Changes in trading patterns are implied by the archaeological evidence from Long Island, and receive some support from linguistics and oral traditions (Ball and Hughes

1982). Most of the prehistoric pottery from Long Island can be attributed to style group I, which has its closest external links with the Madang area. It would seem that about 350-550 years ago Long Island had comparatively close contacts with the Madang area, yet in historic times contacts with the mainland seem to have been mainly with the Rai Coast — Huon Peninsula. Harding (1967: 197) places the eastern limit of the Madang network at Sio, but Z'graggen (1976) and Lincoln (1976) agree that the eastern limit was in fact 160 km west of Sio, but still including the Rai Coast. The Madang style pottery found on Long Island could have been come directly from the Madang area or through contacts with the Rai Coast. Long Island figures in origin stories of the Bogadjim area near Madang (Hagen 1899), and Rai Coast contacts are prominent in the recent oral history of the island as presented by Ball and Hughes (1982). It is possible that the Talasea obsidian on Long Island was obtained from the Rai Coast, which was visited by the Vitiaz Strait traders (Harding 1967: 19), and not through contacts with Sio or by direct voyaging from the Siassi Islands. Lincoln (1976) places Arop in his Korap language subfamily, together with Sel, Singorakai, Malasanga, Lokep, and Barim on Umboi. He raises the possibility that the distribution of this subfamily may reflect a trade network, now defunct, operating between the Madang and Vitiaz Strait networks. More detailed and comprehensive data are needed from archaeology, linguistics and oral histories to test this proposition, as well as the possibility that the production of Madang style pottery was formerly more widespread (*vide* the Yomba Island traditions). For Mailu on the south coast of Papua, Irwin (1977, 1978) has argued a case for the reduction through time in the number of pottery producing centres, accompanied by increasing specialization by one community. A similar development may have taken place on the north coast of New Guinea at Madang or Sio/Gitua, or at both. In historic times Long Island was known as being rich in certain resources (e.g. Harding 1967: 133-4), and this may have been the situation also before the emplacement of the Matapun beds some 250-350 years ago. If this were so, it is unlikely that Long Island would have been omitted from trading networks linking and probably sustaining communities which were resource deficient both on the mainland and in the Vitiaz Strait.

APPENDIX I. RADIOMETRIC AND OTHER DATES FROM LONG ISLAND

Radiocarbon 14 age determinations

All radiocarbon dates cited in this paper are given in radiocarbon years based on the Libby half-life value of 5568 years, with AD 1950 as the reference date. They have not been calibrated against any correction curve to yield calendrical ages. The expressions bp and BP refer to 'before present' with bp for uncalibrated ages and BP for calendrical dates.

During his visit to Long Island in 1972, Hughes collected three samples from exposures of the Matapun beds on the north-west coast:

(a) *ANU-1125:* 380 years ± 70 bp.
Charred wood of *Neonauclea* sp.; age determined on wood cellulose fraction which was isolated by $NaClO_2$ treatment. Sample size adequate; counting for 1540 minutes.

(b) *ANU-1126:* 230 years ± 75 bp.
Charred wood, unidentified. No pretreatment. Sample size adequate; counting for 980 minutes.

(c) *ANU-1127:* 200 years ± 65 bp.
Charcoal. No pretreatment. Sample size adequate; counting for 1020 minutes.

IN 1973 Egloff, Hughes and Specht collected three samples:

(a) *ANU-1307:* 350 years ± 70 bp
Soft charcoal lumps in volcanic ash soil from site JAB/B, collected at two points several metres apart in the artefact-bearing layer in the uppermost unit of the Biliau beds. Examined for rootlets and pretreated with hot 2N HCl at the laboratory. Sample size 67% of laboratory requirements; counted for 1380 minutes.

(b) *ANU-1308:* 1040 years ± 80 bp

Large charcoal lumps mixed with volcanic ash soil from JCB/A, from a layer subsequently identified as the earliest of three palaeosols in the upper levels of the Biliau beds. Soil rinsed from sample in the laboratory, examined for rootlets and then pretreated with hot 2N HCl. Sample size only 53% of laboratory requirements; counted for 1660 minutes.

(c) *ANU-1309:* 470 years ± 240 bp
Soft charcoal lumps mixed with soil, from mudflow deposit at site JCC. Soil washed from sample in the laboratory, examined for rootlets and pretreated with hot 2N HCl. Sample size only 11% of laboratory requirements; counting for 1860 minutes.

Samples ANU-1307 and ANU-1309 were calculated using approximately 95% of the measured activity of the Oxalic Acid C-14 Standard as the modern reference sample; for ANU-1308 the activity level was only 87.9 ± 0.9%.

Thermoluminescence age determinations

Six sherds were submitted to Dr A. Mortlock, Department of Physics, Faculty of Science, Australian National University, for thermoluminescence dating. The determinations are reported without standard deviation calculations. For all samples the annual dose rate was estimated by measuring the potassium content by XRF and the uranium content by delayed neutron activation, with an assumed uranium to thorium ratio of 1:4. For samples 1027 and 1028 the alpha efficiency factor K was measured.

(a) JCB/A sample 1027: 360 years bp (decorated sherd, Fig. 6a).

(b) JCB/B 'above pumice lapilli':
sample 1028: 260 years bp
sample 1029: 410 years bp
sample 1030: 390 years bp
sample 1031: 200-460 years bp

(c) JCB/B 'below pumice lapilli':
sample 1032: 'several hundred years' bp

Obsidian hydration rind dating

Five samples of obsidian from sites JCB and JCC were submitted to W.A. Ambrose, Department of Prehistory, Research School of Pacific Studies, Australian National University, for hydration rind measurements. One piece, sample No. 206, from JCB, was analysed for trace elements by atomic absorption and is considered indistinguishable from the obsidian found in the Talasea area of New Britain. The other pieces have density values within the Talasea range.

The following rind thickness measurements are averages of 30 or more readings per sample:

(a) JCB:	No. 206:	4.2 mm	d 2.347
	No. 207:	4.2 mm	d 2.355
	No. 208:	5.4 mm	d 2.343

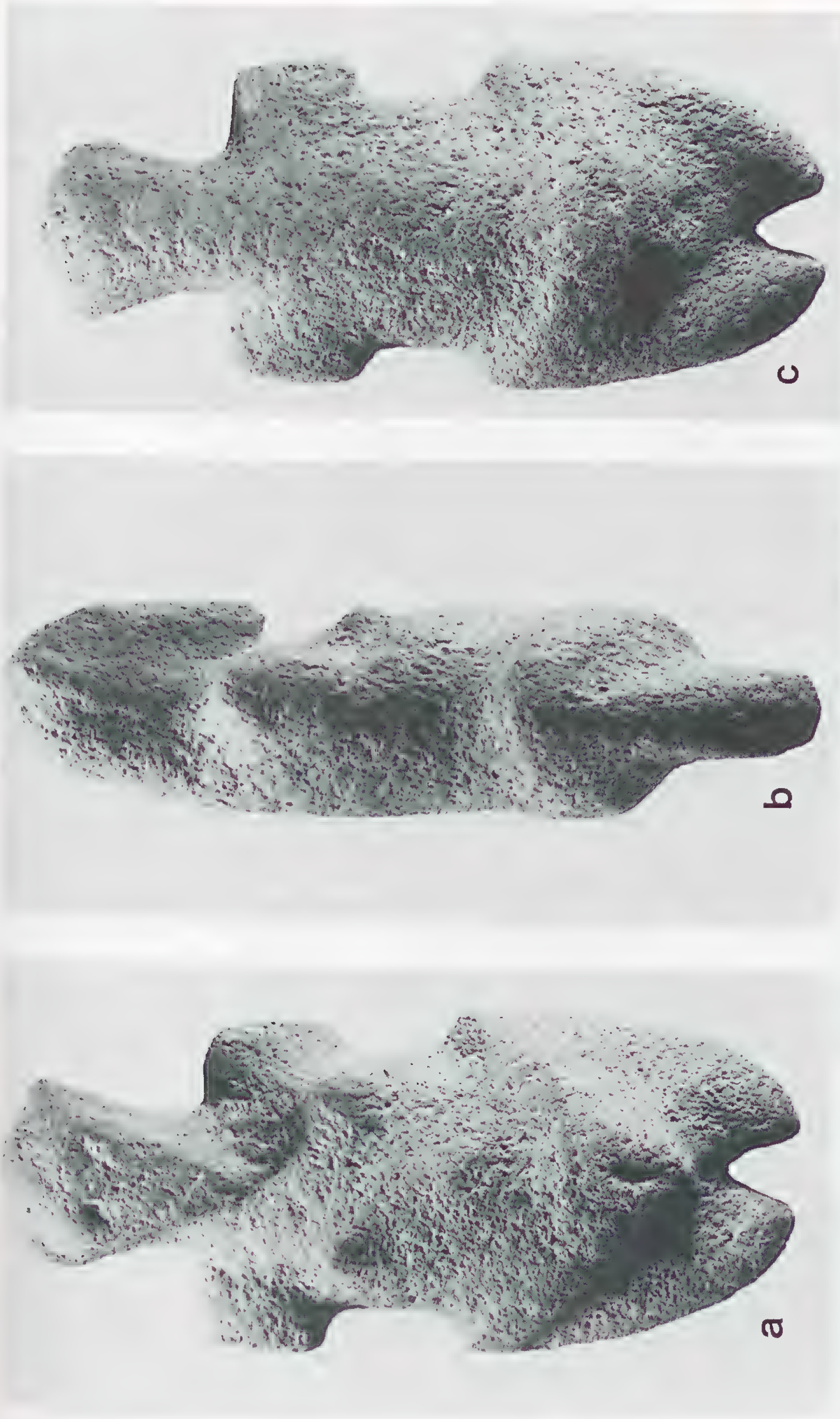


Fig. 7. Long Island: stone figure from Bok, now in Art Gallery of New South Wales, Sydney (reg. No. P2. 1969). Photo by C. Turner (negs. V13282, V13283, V13284). Height: 298 mm.

(b) JCC: No. 209: 5.1 mm d 2.345
No. 210: 5.7 mm d 2.345

These measurements cannot be converted into ages since there are no thermal equivalent values for the sites (see Ambrose 1976b for discussion of these values). Furthermore, these thickness measurements are much greater than might be expected in view of the ages indicated by the other techniques, and the samples may have been affected by the igimbrite eruptions of the Matapun beds, exposure to solar radiation, and possibly other factors which have influenced the development of the hydration rinds.

APPENDIX II. MISCELLANEOUS FINDS FROM LONG ISLAND

Three archaeological finds reported from Long Island have been omitted from the preceding discussions: a stone female figure reputedly found near Bok village prior to 1966, an alleged 16th century Malay *kris* found about 20 years ago, and a stone clubhead recovered by Hughes in 1972. At this stage none of these finds can be related to the archaeological materials described in this paper.

The stone figure from Bok is now in the Art Gallery of New South Wales, Sydney, which purchased it from J. P. Hallinan in 1966. Hallinan had obtained the figure on Long Island from a villager who stated that it had been found near Bok while a garden was being prepared. The figure (Fig. 7) is 298 mm high, made from basalt. It represents presumably a human female figure, with the limbs very schematically delineated. This piece currently appears unparalleled on the mainland of Papua New Guinea.

A *kris* is said to have been dug up on Long Island together with a human skull (see Ball 1982) about 20 years ago. According to R. Caesar, Madang, the *kris* was identified at the British Museum, London, as dating from the 16th century and probably of Malay origin. The present location of this item is not known. While there are many ways in which this *kris* could have reached Long Island, its age as identified on stylistic grounds would place it roughly contemporary with the human occupations of the Biliau beds. Hughes (1977:10ff.) argues that goods of south-east Asian origin may have been reaching New Guinea long before the arrival of Europeans, and specifically notes contacts with Chinese traders in the 15th and 16th centuries. The Long Island *kris* may thus have been brought to the island well before Dampier's passage. At present it is the most easterly known artefact indicative of such possible contacts.

In 1972 Hughes collected a stone clubhead from just north of Kaut village. This clubhead, in a four-pointed star form with central perforation, was found on the ground surface. Its present location is unknown and we are unable to illustrate it.

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Our thanks are due to I. M. Hughes for arranging our visit to Long Island in 1973. Subsequent to that visit, many helpful discussions were held with and much valuable advice was received from Hughes, E. Ball, C. Pain, R. Blong and C. McKee. A. Mortlock, W. Ambrose, J. Menzies, P. Swadling, H. Polach and F. L. Sutherland provided identifications and age determinations. To all of these, our thanks. Our visits to Long Island were funded by the National Museum of Papua New Guinea (Egloff) and The Australian Museum (Specht). The artwork was prepared by P. Greer and Juliet Egloff.

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LONG ISLAND, PAPUA NEW GUINEA — EUROPEAN EXPLORATION AND RECORDED CONTACTS TO THE END OF THE PACIFIC WAR

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SUMMARY

William Dampier sailed past and named Long Island in 1700. His description of the island as green and well-vegetated indicates that the last major eruption of Long Island did not occur in the period 1670-1700. Dumont D'Urville sailed past in 1827 and from his description and those of others who came after him it appears that the eruption must have occurred before 1670 or in the interval 1700-1800.

Dampier in 1700 described a boat coming off from the shore of Crown Island and the Morrells in 1830 describe people and huts on the shore of Long Island, but the first reliable description of villages and the first contact with the people date from the visits of Finsch in 1884-5. Thereafter periodic brief contacts continued, at irregular intervals, up to the 1930's. Members of the German Südsee Expedition visited the village of Soraga in 1909 and collected names which provide a useful fixed point in the genealogies of the islanders. During the 1930's the ornithologist, William Coultas, spent several months on the island and there were periodic visits by Europeans interested in starting coconut plantations. World War II brought the islanders their most extensive contacts with the outside world as the island was first visited by a few small parties of Japanese and then in late 1943 it was occupied by an Allied force.

HISTORY OF EUROPEAN EXPLORATION AND CONTACTS

Records of knowledge about, or contact with, Long Island are important for the following reasons: they allow us to say with certainty that the last devastating eruption of Long did not occur during certain intervals and tell us something about the state of the vegetation on the island at certain dates; they allow us to say when people were first reliably described as living on the island and the names collected by the German expedition of 1909 provide a fixed point for dating the genealogies of the local people; and, we can gain some idea of the degree of outside contact experienced by the people and of the state of their culture at different dates. There are relatively few records of contacts before 1900, which has made it possible to present those which do exist essentially in full. Only in connection with contacts during World War II was more detail available than could be presented here.

Asian traders may have reached Long Island before the first Europeans but there is no definite record of this. A Malay *kris*, now lost, was found buried in association with a skull on Long Island and has been identified at the British Museum as dating from the 16th century (R. Caesar, pers. comm.), but its significance in terms of the history of the island is unknown since it could have been in use for a long period after its manufacture and it might have reached the island as a trade article. The possibility of early Asian imports to the north coast of New Guinea, either by visitors or via Melanesian canoe trading systems, has been discussed by Hughes (1977: 10-18). Also, Malays and Javanese were employed in considerable numbers in the Madang area in the late nineteenth and early twentieth century by the Germans (Hughes, 1977: 38).

Records of the Australian Museum, 1982, **Volume 34 Number 9**, 447–461, Figures 1–3.

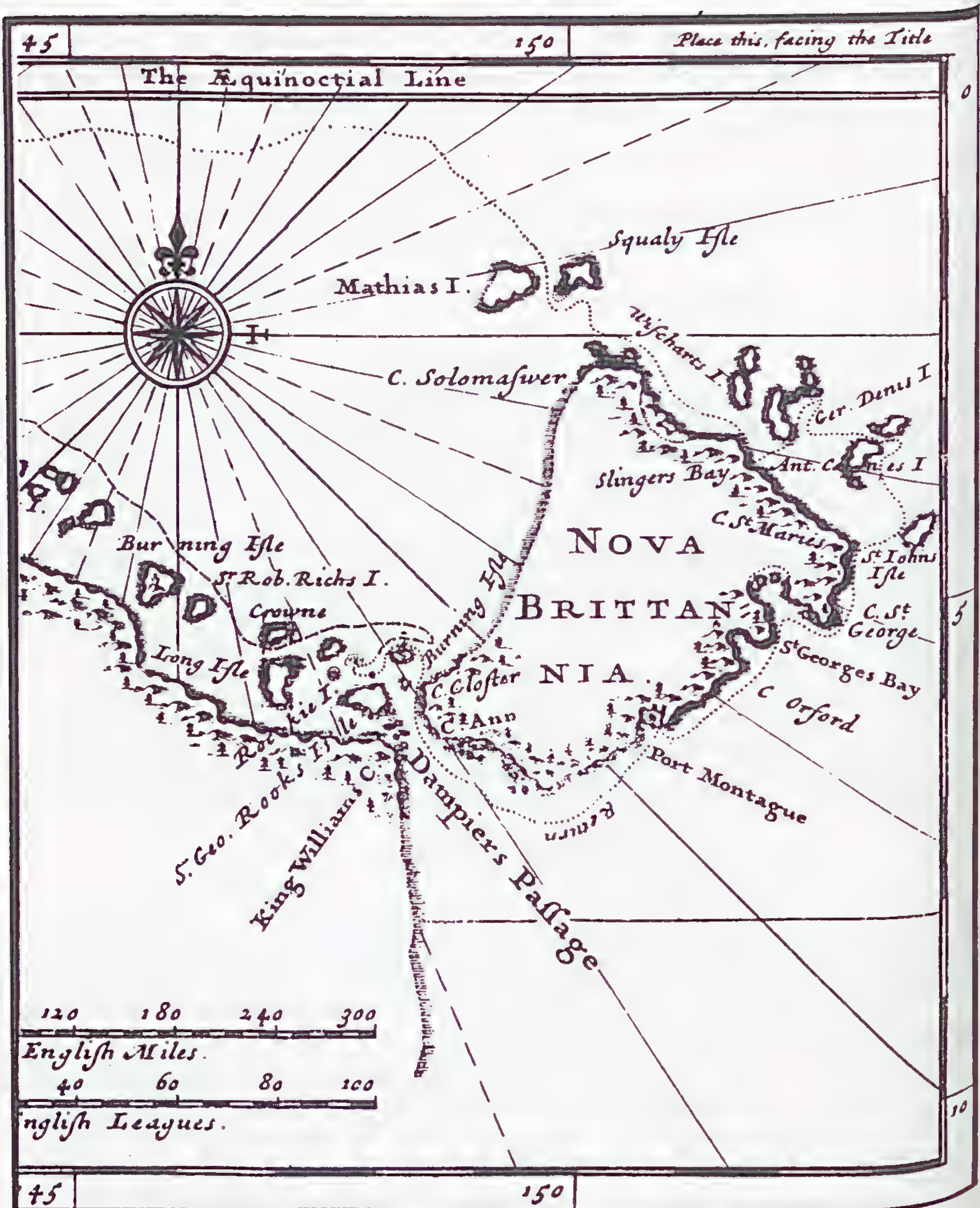

Figure 1. Portion of chart labelled "A View of the Course of Capt. Wil. Dampier's Voyage from Timor Round Nova Brittania & c." p. 208 ff. in Dampier, William. 1729. *A Voyage to New Holland*. J. A. Williamson (ed). The Argonaut Press. 1939.

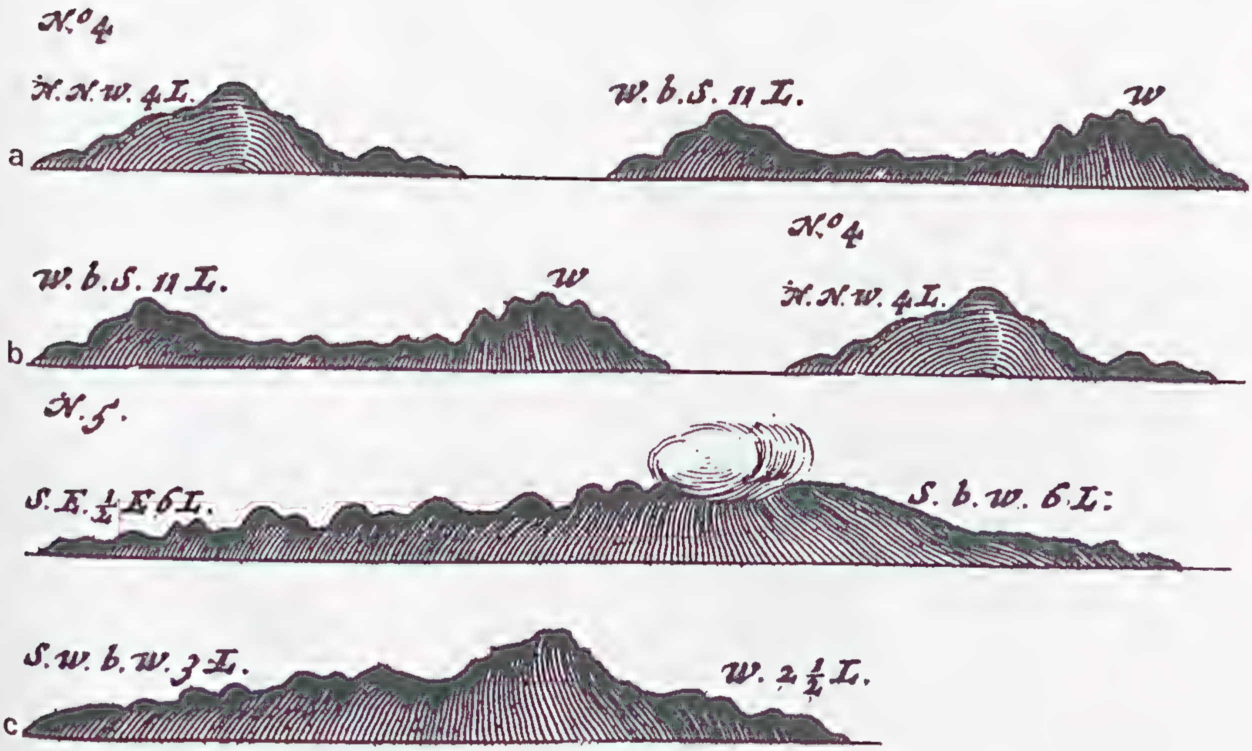

Figure 2. A. Table 13 No. 4 as figured in Dampier, showing Long Island and Tolokiwa Island. b. Table 13 No. 4 redrawn according to the coordinates. c. Table 13 No. 5 of Dampier. According to Cooke's analysis these are Long Island and Crown Island.

Ynigo Ortiz de Retes may have seen Long Island in 1545 (Wichman 1909: 26) but the first well documented sighting by a European was by Abel Tasman in 1643 (Wichman 1909: 93). Tasman, however, mistook Long Island for a part of the mainland (Reche 1918).

In March 1700 William Dampier sailed past Long Island and named it. He describes these events as follows (1729, 1939 edition: 218-219):

> The 31st in the Forenoon we shot in between 2 Islands, lying about 4 Leagues asunder; with Intention to pass between them. The Southermost is a Long Island, with a high Hill at each End; this I named Long Island. The Northermost is a round high Island towering up with several Heads or Tops, something resembling a Crown; this I named Crown-Isle, from its Form. Both these Islands appear'd very pleasant, having Spots of green Savannahs mixt among the Wood-land: The Trees appeared very green and flourishing, and some of them looked white and full of Blossoms. We past close by Crown-Isle; saw many Coco-nut-Trees on the Bays and the Sides of the Hills; and one Boat was coming off from the shore, but return'd again. We saw no Smoaks on either of the Islands, neither did we see any Plantations; and it is probable they are not very well peopled. We saw many Shoals near Crown-Island, and Riffs of Rocks running off from the Points, a Mile or more into the Sea. My Boat was once over-board, with Design to have sent her ashore; but having little Wind, and seeing some Shoals, I hoisted her in again, and stood off out of Danger.

A map of Dampier's cruise in the area northeast of New Guinea is given in Figure 1. Dampier made profile drawings of the islands which he encountered during his travels along the north coast of New Guinea and these are presented as Tables 13 and 14 in his book. However, they are unlabelled and are not incorporated into the text, so the reader must decipher them as best he can. According to Williamson (editorial notes on page. VIII of the 1939 edition of Dampier, 1792) lack of close correlation between the illustrations and the text is due 'to the fact that Dampier was at sea when

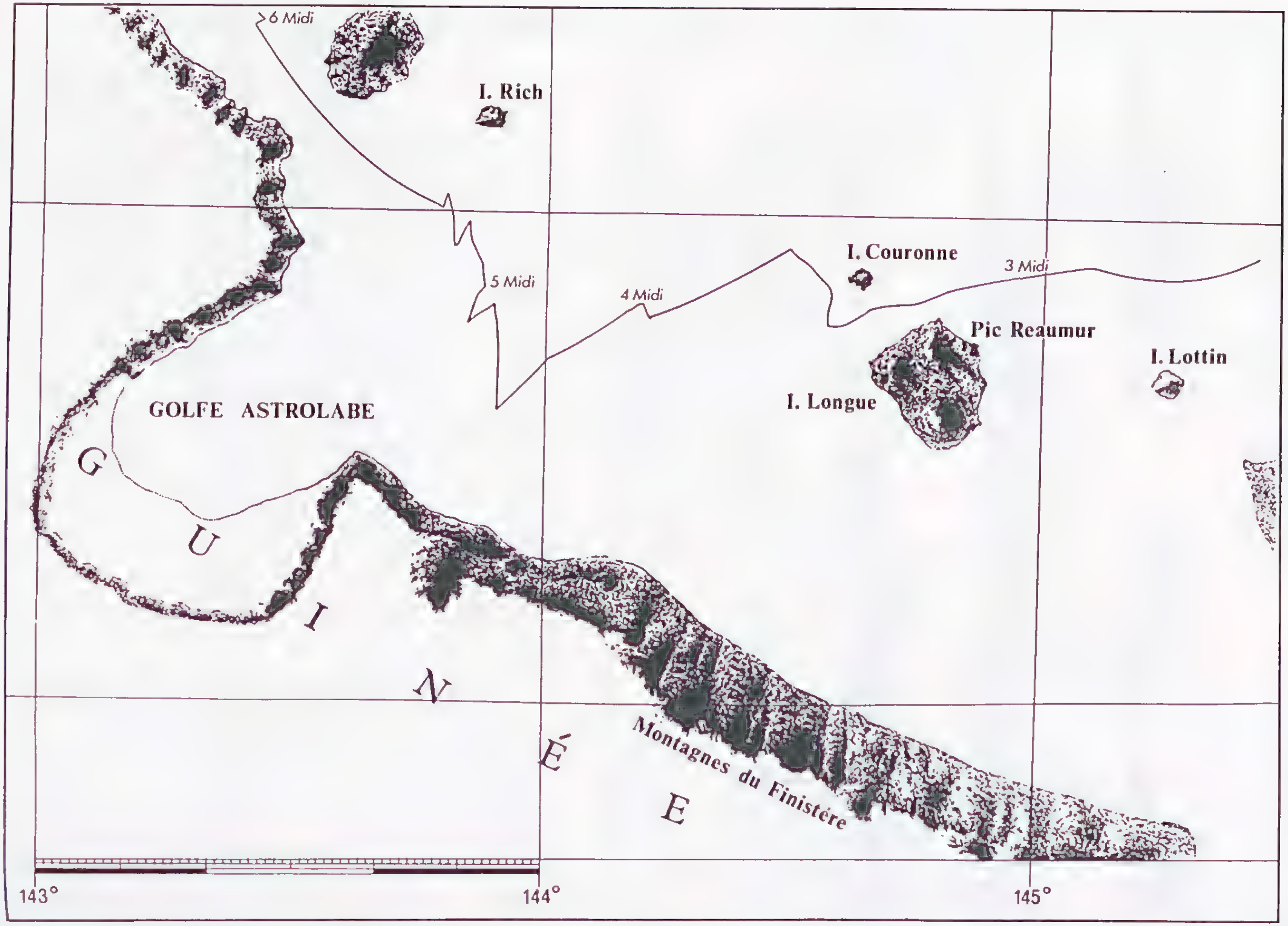

Figure 3. Portion of 'Carte Générale de la Côte Méridionale de la Nouvelle Bretagne' redrawn from Dumont D'Urville, J.S.C. 1833. Voyage de découvertes de l'Astrolabe exécuté par ordre du Roi, pendant les années 1826-1827-1828-1829. Atlas Hydrographique. Paris.

the second part of his book was printed and was dead when the second edition appeared in 1729'. Following Reche's (1914) careful analysis, which assumes that the profiles are sequential, Long and Crown must be found in Table 13 #4 or #5. Examination of #4 shows that the bearings given are not consistent with the way the islands are drawn. If the figure is redrawn according to the bearings it is consistent with the islands being Long and Tolokiwa (R. J. S. Cooke, pers. comm.). Cooke further found that Dampier's Table 13#5 shows Long and Crown islands. The island profiles are shown in Figure 2.

The next explorer to give any details about Long Island was J. S. C. Dumont D'Urville, who sailed past in August, 1827 and named the two peaks. The northern peak he called Réaumur, after the physicist R. A. F. de Réaumur, and the southern peak he called Cerisy, after the naval architect Lefébure de Cerisy (Wichman, 1909: 327). A redrawn version of Dumont D'Urville's map of Long Island is shown in Figure 3. Although his track between Long and Crown Islands was in general similar to Dampier's (compare Fig. 1 with Fig. 3), his description of Long Island is quite different (1832: 543-544):

> At one o'clock, we were already beneath the steep and rugged flanks of Mt. Reaumur, which also appeared to have been a volcano, and we followed, at a distance of less than two miles, the deserted beaches of Long Island.
>
> This island was quite incorrectly named by Dampier, probably because of the first view of the island which that navigator saw, because it has a rather round shape and its circumference is not less than forty miles. The ground in the vicinity of the shore appeared more arid than all the other islands and we saw neither coconut trees nor any trace of inhabitants.
>
> Crown Island, which is no more than seven miles to the NW of Long Island, is a plateau four or five miles in circumference and of great height. The ground, although rugged, showed no sign of the sharp ridges which caused Dampier to give it the name Crown Island. Perhaps because the irregularities had been effaced by the growth of forest with the passage of time, perhaps because that navigator, having passed closer to the island than me, was in a better position to see these things. There was no sign of smoke nor inhabitants; the sea was so calm that it is probable we would have seen a few canoes, had the island been inhabited.

The next description, from the year 1830, is in the accounts of Benjamin (1832) and Abby Jane Morrell (1833), each of whom wrote a book about their cruise aboard the schooner 'Antarctic'. The narratives are essentially the same, so only Benjamin's, which contains slightly more detail, will be quoted here (1832: 459):

> I have introduced the foregoing particulars in this place, because the reader is now to be informed, that on the 12th of November, at five, P.M., the Antarctic was on her way to this coast, from Dampier's Island [this must refer to Umboi judging by the direction Morrell was sailing , although most charts at this time applied the name Dampier's Island to the island now called Karkar — R. J. S. Cooke, pers. comm.] sailing at the rate of thirteen miles an hour, on a sea which was smooth as a mill-pond, rendered so by the current that set through the strait towards the north-west, at the rate of four miles an hour. At six, P.M., we were within one mile of the north shore of Long Island, which is about the same size as the one we had just left, Dampier's Island, but not so much elevated. We saw a few scattering huts along the banks of the seacoast, and a number of natives about them, who made signals for the vessel to stop. But the wind coming off from the land in strong gusts, and wishing to get clear of the island before dark, we continued our course to the westward, until we had cleared the western end of Long Island; when we immediately hauled in to the south, for the north-east of New-Guinea, or the island of Papua.
>
> I feel it a duty in this place to put mariners on their guard, by stating that there are many dangerous coral reefs around the two last-mentioned islands; some of which

extend several miles into the sea.

These observations seem straightforward, but may not be dependable since other portions of his account are patent fabrications.

Judging from the accounts of Wichman (1909, 1910, 1912) many other sailors must have sighted Long Island between 1800-1900. Among them was Robert L. Hunter, who sailed past Long Island in 1840 and commented that the whalers called it Crown Island (Wichman 1910: 50). Francis John King, who passed near Long Island in 1842, made the following comments (1844: 12):

> Antediluvian Island — 6th, made a round island about two miles in circumference, surrounded by a reef which stretched to the south-east, towards Long Island, on which the Lady Blackwood struck, in 1840, making a passage between the two islands. This island I called Antediluvian Island, and is uninhabited; by good observations is in lat. 5° 45′ south, long. 146° 50′ east. The abovenamed islands and reefs are not layed in Horsburgh's, Norie's, or any charts on board the Waterwitch, or any I have hitherto seen.

I have checked the coordinates given by King for other localities and found them to be generally quite accurate, with errors of only a few minutes to N and S, so there was no systematic error in his readings. I have been unable to locate the charts mentioned by King, but since Long and Crown Islands were both named by Dampier on the same day it seems unlikely that the charts would show one without the other. Nevertheless, it seems most likely that King's Antediluvian Island is Crown Island, since transposition of 5° 15′ and 5° 45′ is an easily explicable mistake, and everything else seems to fit. Another possibility, which appears less likely, is that King meant 4° 45′ S, in which case he might have been referring to an island where Hankow Reef now is.

There were Marist missionaries on Umboi in 1848-1849 and missionaries from the Institute for Foreign Missions of Milan were there from 1852-55 (Wiltgen 1969: 329; however, it appears from Reina 1858, that they were still there in 1857), but Rev. R. M. Wiltgen (pers. comm.) has found no mention of contact with the people of Long Island during his extensive researches on the history of these missions.

In 1884 Dr Otto Finsch travelled extensively along the northeast coast of New Guinea. Two portions of his report relevant to Long and Crown Islands are given below (1885a: 4; 1885b: 5 respectively).

> On Oct. 10 we travelled along the north coast of Crown Island, which has the form of a conspicuous, thickly wooded mountain approx. 1500′ high; neither coconut palms nor traces of people were to be seen. Long Island and Dampier Island [Karkar I.], as well as Rich Island we saw from afar. All are thickly wooded. Here there are reefs everywhere, so that sailors must be very careful.
>
> On the 29th [November, 1884] we travelled along the SE coast of Long Island as Dampier Strait is very dangerous because of many reefs and we had realised for a long time that one could put little or no trust in the charts. Long Island is mostly thickly wooded or covered with scrub and has no coconut palms or people; or at least it is very thinly peopled, for we saw only 2 or 3 small settlements in inaccessible bays whose inhabitants came offshore in a canoe and were difficult to persuade to come closer. The island has no harbours and hardly any anchorages.

In 1885 Finsch paid a more extended visit to Long Island (1888: 188-189):

> Then we steamed northwards to Long Island, along the eastern side of which we passed. It seemed to be of a similar character to Dampier [Karkar I.] being entirely volcanic with several extinct volcanoes of which three forward projecting cones lay before us next to Coriz Peak. The latter may be 4,000 ft high and is thickly wooded as are the other peaks. Opposite Coriz Peak on the northeast side lies the somewhat

lower Mt Reamure, but Findlay (Pacific Directory, pg 931) errs when he says that the two peaks are separated by a deep valley. [I have been unable to sort out which name Finsch is associating with which peak. This is also the earliest mention I have found of Coriz Peak. D'Urville showed three peaks on the island but did not name the third.] The whole island is mostly mountainous, with very little flat land and only moderate ravines or valleys passing through it. The coast appears as unpromising as the land itself, which should, however, be easier to cultivate than Dampier I. [Karkar I.] since it doesn't have such thick virgin growth but shows more undergrowth-covered areas. The shore was mostly a not very high, steep rocky cliff, which sometimes became lower and formed shallow bays, which however would scarcely be useable as harbours, at least not on the east coast which we were steaming along. Plantations were nowhere recognisable, but in the second bay I noticed a yellow tree and some coconut palms, the only ones which we saw on the entire island. And — "there are the black customers already!" said the steersman. In fact, a sailing canoe with eight passengers came slowly out of the bay, but still no closer. Then the lungs of the black from Mioko again had work in a way that was familiar to them from their travels aboard labour recruiters, "Good ship that fellow, plenty to eat, plenty of tobacoo, plenty of women, plenty of laplaps, the captain is very good, come quickly, quickly!" Only this time the "we buy people" was omitted for the Samoa certainly had nothing to do with that. That of course, made no impression on the Long Islanders for they understood of this speech as much as we did of theirs: nothing; and with that we got along perfectly well, as the canoe finally slowly moved towards us. The people, who were by the way true Papuans and exactly like the inhabitants of the mainland of New Guinea, were not greedy and were willing to barter. But they had nothing much, only things such as are found in Astrolabe Bay, e.g. woven armbands, breast decorations and the same kinds of bows and arrows. When they had sold almost everything [they had with them] they gave the prow of their canoe and cut away even the painted sideboard. Among these [parts of the canoe] were quite noteworthy little items, for example from the tip of the mast a triangle with crudely carved birds, a strange frame on the outrigger and so on; all objects which now may be seen in the Museum für Völkerkunde in Berlin, which previously probably did not possess any pieces from Long Island. As provisions only some old coconuts and leaf tobacco were brought. The people did not appear to be familiar with trade tobacco, in contrast to glass beads and iron, which here was greeted with the cry "gari". In the excitement of trading the newly acquired knife of one of the men fell into the water. Then one could see a grieved black, since for such a child of nature this is scarcely something to laugh about. Now I like to see happy people, so I gave the man another knife, and one could again rejoice in a happy black face. Probably today I am still favorably remembered; for the blacks remember good as well as bad, and probably tales are still told of the strange ship without sails and the white man with the red beard. He must have been rich! Yes, I have not lacked knives since my boyhood, least of all on the Samoa, which carried many gross.

In 1885 Captain Cyprian Bridge, of H.M.S. 'Dart', landed on the south point of Long Island and declared it a British protectorate. His description of the event is as follows (1885: 2003-2005):

14. Dull weather and heavy rains, during which dangers could not be discerned till close to, prevailed on January 16th, on which day the "Dart" reached Long Island. After examining the eastern and south-western shores without being able to discover any natives, I directed Lieutenant and Commander Moore to return to the southern point at which I landed, and having on a bluff some 40 feet high above the sea set up a flag-staff, hoisted the British flag and read the Proclamation. A copy of the Proclamation was nailed to the flag-staff.

Bridge was accompanied by the missionary James Chalmers, whose account is slightly more detailed (1887: 222-223):

By 7.30 we were in the open, in a deluge of rain, steaming to Long Island. This is another of those at one time active, living volcanoes, now dead, living only in newer life and truer beauty. From the base of the highest peak — 1,500 feet — a long low

ridge runs, which, when some distance off, gives the appearance of a very long island. We sailed well round it, but could see no appearance of living beings, neither house nor plantation. We could not land on the north west side, so decided to hoist the flag on the high south side on a prominent place. We landed, and ascended an embankment of volcanic earth, about forty feet above sea-level, and there dug a small hole, close by a stump. The pole was raised and fastened to the stump, and again Captain Bridge performed the ceremony. The opportunity was favourable to address the officers and men, and in kind and well-chosen words he told them how pleased he was with the manner in which the work had been done, and what satisfaction he would have in reporting to the proper quarter respecting Captain Moore, his officers, and men.

There must have been at least one unrecorded visit to Long Island sometime before 1900 as shown by the following quote (PNG Govt. — Patrol Report — Anonymous — Saidor 4 of 1951/52):

People very natural and eager to please and most hospitable to the patrol. Apparently this has not always been the case, because the O.I.C. was presented with a piece of grapeshot that had fallen from a dead tree — possibly the mark of a visiting ship early in the last century.

On February 9, 1900, Governor Rudolf von Bennigsen and a plantation owner named Boag passed near Long Island aboard the 'Johann Albrecht' but did not anchor. However, two men in 'fighting regalia' came alongside in a canoe and received many gifts and the promise that the Germans would soon return. Bennigsen (1900, 324) described the island as apparently fruitful and well-wooded and as being only thinly populated by a tribe of people who appeared to be related to Papuans.

Dr. G. Friederici passed Long Island in 1909 and reported only that 'Long Island has high, no longer active volcanoes at the north and south ends' (Sapper 1910: 256).

Also in 1909 the Südsee-Expedition der Hamburgischen Wissenschaftlichen Stiftung stopped briefly at Long Island, and the reports of this expedition provide several good accounts of conditions at that time. The first of these is by Otto Reche (1954: 89-90; translation by V. B. Meyer-Rochow):

On the 7th of May 1909 early in the morning we were awakened by a very strong thunderstorm. "Peiho" is going to Long Island which is not long at all but does look rather long if you approach it from the east. Approaching the island the captain reported from the bridge that the inhabitants of the village being approached were standing on the shore ready to fight, which is why we left the valuable instruments and trade articles safe on board. However, when Hellwig, Reche, Muller and Vogel came ashore to the village of Sora, they were met, to their great surprise, with complete, almost cultivated, friendliness and in particular — this had never happened to us before — mainly by a woman about 40 years old who immediately approached us with her elastic and energetic walk smiling in a friendly manner and asking us our desires and begging us to come closer. Although for a native woman 40 years old, she was no longer young, and although she had very gray hair, she was of a youthful liveliness and had a vivid energetic character. She was to be seen everywhere around, seemed to lead the rest, helped wherever she could and in general seemed to play the important role in the village and seemed to be at least one of the responsible important townspeople. Mrs Tagere (as she was called) was an exceptional personality of almost European character of whom we had never seen the like anywhere else on our expedition. We were told that she was a widow and that she was looking after the orphans in the village (this could have been a misunderstanding for in the little village not many orphans could have existed). Anyhow she was the soul of the village and all our success in this settlement we owe to her. What we had never heard anywhere else before was that she could even laugh with a high-pitched voice. She seemed to look after conduct and education in the village.

Even the young people were faultlessly polite. They picked up every little stone which

was lying in our path so that we wouldn't hit it and if we happened to throw something carelessly away while eating, e.g. a banana peel, then they would pick it up and dig it into the soil for in this region there is a general belief that with these discards black magic can be made and they wanted to save us from this. As a matter of fact the people were much more polite than we were and, by the way, Chief Aijile [original German spelling] did not neglect his duties either. He invited us to sit down in the shade of his house and in return for our presents of tobacco gave each of us a cane of sugar and some taro. He was a strong personality. The people were of the same type as those found on Lottin and equally light-skinned.

There is another reason from which one could deduce that those people were on a considerably higher mental and emotional level than most of the natives here. The dogs and pigs were exceptionally tame and friendly which we took to mean that they were usually not treated in a cruel manner as is usually the rule with kanakas. Here it seems that one normally has a sort of psychological relation to animals and does not treat them as lifeless things. With all this helpfulness and friendliness of the natives Reche could finally do some anthropological work. However, he measured only one man but took several photographs, among them some of our friend Mrs Tagere. Skulls were nowhere to be seen and could not be purchased.

Remarkable were three incurably ill people which we found in one house. They were as thin as skeletons and could move forward only in a sitting position. They did this crawling, pulling with their hands and thus slowly moved themselves forward. One man and 2 women suffered from this disease the nature of which Fulleborn also could not determine since he had not seen it. He had remained aboard the ship to work through the results of the cruise. Similar cases we had seen rarely in other villages of West New Britain.

At first only few people were to be seen in the village but they soon came closer, particularly after the chief had ordered them to come. The village had five houses on stilts and two houses flat on the ground which were of the type we had seen the last few days. Hellwig could record all five names of the villages on the island and the names of the house owners in the largest village Ow [original German spelling]. Muller was able to record a small vocabulary. Our trade ended with us buying a pig, which was longed-for fresh meat for the "Peiho". The relatively large island appears to consist without exception of older and younger volcanic stones and ashes. When we left our gay friend waved goodbye for a long time to which we had to reply in a similar vigorous manner. When "Peiho" sailed we couldn't see any of the other villages described to us. "Peiho" went on toward the Siassi group to go to Tuam.

A second account by G. Thilenius provides considerable overlap with that of Reche but, as there are some differences, the Thilenius account is also presented in full (1927: 151-153, translation by V. B. Meyer-Rochow):

7 May, 1 o'clock, strong thunderstorm, "Peiho" approaching Long Island which when approached from Tupinier nicely fits its name — a long coast flanked symmetrically by 2 cones. Hellwig, Muller, Reche and Vogel land at 9 o'clock on the part of the shore which appears to be inhabited after a long boat trip. The captain had reported from the bridge that the natives were in fighting regalia so all of the more important scientific instruments and articles of trade were left aboard and weapons were substituted. The gentlemen therefore were happily surprised when they were met in a friendly manner by the natives. Particularly noteworthy was the fact that a woman about 40 years old not only led the greeting ceremony but also all the discussions. In general she appeared to be the soul of the village community with her energetic walk and equally energetic voice. Mrs Tagere invited us to go to the village where her commanding voice and her peculiar manners along with her youthful liveliness and gay laughter were always a source of happiness. The name of the village was Sora and consisted of 5 houses on poles and two houses flat on the ground all of which were similar to those we had seen during the past few days. In addition there was a good stable with a high fence for one pregnant sow. Of the two houses on the ground one was inhabited by men, the other by 2 incurably ill people who could only move forward by crawling along and pushing forward with their skeleton-like legs and pulling forward their body

> with their hands while supporting themselves with their hands. Altogether there were 3 of these ill people, one man and two women. We had seen similar cases in several villages in Western Neu Pommern [New Britain], Fulleborn presumes neuritic reasons. There was also one completely mentally retarded boy with an abnormal head formation and bent legs who we found squatting under a house. In general the population (which consisted of 5 men and 11 women and girls), which was of the New Guinea type, had remarkably good figures. The chief, Aijile, himself was a remarkable personality and invited us to sit in the shade of his house and he politely supplied each of the whites with one taro and one sugar cane in return for our presents of tabacco. He also called the hidden women and children who rapidly lost their shyness and became confident so that Reche was able to do some anthropological work. In the meantime Tagere critically was examining all trade items of Hellwig. Without her consent no piece was allowed to change its owner. Muller, as soon as he could work with Sagails, recorded a small vocabulary while Vogel was drawing. Hellwig investigated the names of 5 more villages on the island and recorded the names of 19 house owners in the largest village of "Ow". The tameness of pigs as well as dogs on Long Island is remarkable. It is, as in the western parts of Neu Pommern, the consequence of a mild treatment in contrast to the very brutal treatment in the eastern parts.
>
> After Reche had taken some probes of the volcanic stones near the village as well as sand and pebbles from the shore the whole expedition went aboard again and we had to reply for a long time to the energetic goodbye waving of our never tiring Tagere. After one o'clock in the afternoon we were back on board where Fulleborn, writing his expedition report, in addition was observing the cloud formation on top of the 2 mountain peaks of the island. The clouds were covering the peaks ring-like as we had observed on Tupinier and Lottin Islands, the latter of which we had climbed and found ourselves in heavy rain while at the same time the sea was in brightest sunshine. While Duncker's boat went out for two hours to fish, the whole expedition tried in vain to find any signs of any of the named villages on the west side of the island. "Peiho" then set its course SE at 5 o'clock to steer toward Tuam of the Siassi group.

Hans Vogel-Hamburg (1911) of this same expedition attended a large singsing at the village of Sikawa, which was on Sio Island on the Rai Coast. Also in attendance were 'magnificently decorated inhabitants of Long Island, whose villages have unfortunately remained hidden from us' (1911: 256).

G. Evans (1940: 44) landed on Long Island in 1925 and described it as 'so far as we could judge . . . uninhabited.' However, this statement was based on a stay of only three days, with mobility apparently limited by bad weather.

The first published mention of Lake Wisdom appears to be that in the *Official Handbook of the Territory of New Guinea* (Australian Prime Minister's Dept. 1937: 96) which contains the following quote:

> A party landed on Long Island in February, 1928, and after climbing the steep sides of a mountain to a height of some 1,500 feet, looked down on the waters of a lake, about 4 miles by 5, about 1,000 feet below them. The shore natives, numbering approximately 300, are immigrants from Siassi Islands: they declare that the heights are inhabited by natives whom they have never seen, but whom they blame for the disappearance of their women from time to time. The name Lake Wisdom was given to the lake. It is interesting to note that in 1921 the island was reported as uninhabited.

The lake was named after Brigadier General E. A. Wisdom who was Administrator of the Territory of New Guinea from 1921-1933.

William Coultas (1933-35) of the Whitney South Sea Expedition collected birds on Long Island in November-December, 1933, and his unpublished journal provides a wealth of information about many aspects of Long Island life. The Coultas party was only the third to live on the island, the previous two parties consisting of Australian government patrol officers (see below). Only information relating to previous contacts with the outside world will be dealt with here. These are summarized by Coultas as

follows (265-266):

> Owing to its isolated position and lack of facilities for ships, Long Island is probably the largest island in the Mandated Territory without a white trader or planter. Not even the mission societies have penetrated here. The two-hundred odd natives are visited by the Patrol Officer of Madang District twice per year and reasonably often by a Japanese or Chinese fisherman. Less often by recruiters in need of fresh food for their crews. A few boys, who have been returned from working on plantations, speak fairly good [pidgin?] English and are only too willing to act as interpreters. A ship is, naturally, the cause of much excitement . . .

A German visit, of which I have been unable to find any other record, is described as follows (275):

> The old men called our attention to the place where the German steamship had anchored when the boys were taken away to Madang. Only one of these boys returned — a really fine old kanaka who spoke both [pidgin?] English and Malay and acted in our behalf many times.

Those who left the island as labourers and later returned must have had a great effect on their society both in terms of their ideas and experiences and the material things which they would have brought back. Two such men, Sili (Father: Goreke) and Bara (F: Dagas), were still living on the island in the 1970's and information obtained from them is presented in Ball and Hughes (1982).

Coultas climbed to the crater rim above Lake Wisdom, but due to the steep inside walls of the crater he decided, as had a patrol officer and a doctor before him (Coultas, 269-270), not to attempt to descend to the lake.

No pre-war patrol reports have been located. However, the following information was published by Carey (1938):

> Mr Nurton, Patrol Officer, who visited the island in 1932, estimated from native lore that the catastrophic explosion which formed the caldera occurred about 300 years ago. The rain of ash and debris destroyed all life on the island as well as on Crown Island 12 to 15 miles to the north-west, and deaths occurred in the Siassi Group over 60 miles away. The present inhabitants are descendants of Siassi Islanders who colonized the island three generations ago.

No European missionaries have lived on Long Island but, starting in 1925, Sio evangelists lived there (T. Harding, pers. comm.). In the late 1930's or early 1940's there were two native mission helpers, working from Umboi for the Australian Lutheran Mission (Allied Geographical Section 1943a).

Also during the 1930's, L. J. Bell started a plantation at Bokbok on the west coast (Allied Geographical Section 1943a; Nauna of Matapun, pers. comm.). Bell recruited labourers (including Sili [F: Goreke], Bara [F: Dagas] and Botsai [F: not recorded]) set up a plantation, and got trees planted but he spent little time on the island. His boat was the 'Bulolo'. The plantation was deserted after 2-3 years due to the start of World War II. Franz Moeder (pers. comm.) also started a plantation in the late 1930's which was abandoned with the start of the war. According to Moeder, trochus and bêche-de-mer fisherman used to visit Long Island fairly frequently during the 1930's when there were several Japanese-controlled companies operating out of Manus. Also, sometime during the 1930's a Japanese aboard the 'Sanksi' brought in Manus swimmers to fish for turtles and took hundreds for oil (Moeder and the people of Kaut, pers. comm.).

The first visit to Long Island by a geologist was apparently that of N. H. Fisher in 1939. He reported (1939) that there was no trace of active volcanism nor was there an island in Lake Wisdom.

During 1942 the coast watchers (Allied Intelligence Bureau) were the only Allied Forces in the area of Vitiaz Strait. L. J. Bell at least once used Long Island as a place of refuge while serving as a coast watcher in 1942 (Feldt 1946:178).

In early 1943 there was considerable air and naval activity in the Vitiaz Strait area. On February 28, 1943 a convoy of eight ships escorted by eight destroyers left Rabaul carrying 6000-7000 men who were intended to strengthen the Japanese force at Lae. This convey was almost completely destroyed by Allied air power. Following this demonstration of Allied air superiority the Japanese were forced to rely on submarines and small craft which moved only at night to supply their forces in the Lae area (Gill 1968: 272).

I have not found any published accounts of the Japanese having garrisoned Long Island, but it was important as a staging point for barge movements between Rabaul and Wewak (US Army, Office of the Chief Engineer GHQ, 1959: 181). However, Angus (F:Botsai) of Matapun states that the Japanese camped at a deep cove south of Matapun for perhaps a year before American planes strafed the camp and killed some of the Japanese; after this the survivors left. In this connection it is interesting to note that aerial photos taken of Long Island on September 28, 1943 (mission 270 Z 28 September, 1943 Film 8551 frames #3 and #5, Film 8534 frame #37) show what appears to be a barge near shore near the present site of Matapun.

As the war turned against the Japanese during the last half of 1943 the Allies moved gradually northward. In preparation for an Allied attack on Cape Gloucester, a party of three Europeans of the Allied Intelligence Bureau and four nationals was landed from a PT boat on the northwest shore of Long Island on October 6, 1943. Their mission was to get information as to any force on the island and establish an air-watching post to report air attacks from Madang. At the time of their arrival there were at least two parties of Japanese on the island, but within a few days both groups had left. The coast watchers then moved to the outskirts of the nearest village (presumably Malala) and from here aircraft were reported while patrols circled the beaches of the island. By late November it had been established that the island was free of Japanese and a signal to that effect was sent to headquarters. The party remained on Long Island for another month, reporting aircraft and submarines, until Allied forces arrived (Feldt 1946: 333-4). Near midnight on December 23 the commander of the force that was to occupy the island and two scouts were landed on Long Island from a PT boat. The commander remained on the island only long enough to be informed that there were no Japanese there and then returned to Finschhafen. The scouts remained on the island to carry out further reconnaissance and to display range lights on the night of the landing to guide in the landing craft.

The occupying force, consisting of 150 men from the 592nd Engineer Brigade, 2 amphibian scouts and 33 men of the 338th Australian Radar Station, left Finschhafen during the afternoon and evening of December 25 aboard 5 LCM's, 3 LCVP's and 3 PT boats and the first men from the PT boats were ashore by 0200 on December 26. The landing craft had to alter their landing site to a beach south of Cape Reaumur due to heavy surf and did not make it ashore until 1300. The radar was set up within a few days and camps and trails were established and improved. However, the monsoon season arrived with heavy rains at the end of December and by January 1 these had put the radar out of commission. The Japanese failed to attack Long Island and most of January was spent patrolling the island and getting the radar into operation. Later a large radar screen was established on the slopes of Mt. Reaumur above Poin Kiau at the northern tip of the island. Heavy rains caused occasional flash floods, one of which collapsed a river bank on which a bulldozer was parked. The strength of the current was such that the bulldozer was swept down the river and out to sea. In early February an airstrip 50 feet wide and 1500 feet long was constructed just west of Poin

Kiau for use by light observation aircraft (US Army, Office of the Chief Engineer GHQ, 1959; Angus [F: Botsai], pers. comm.). In mid-February the amphibian engineers were removed from Long Island and replaced by an infantry unit. Later in the war Allied flying boats landed on Lake Wisdom from time to time (John McAlpine, pers. comm.). Sometime during the war a PT boat apparently went aground near Kaut (pers. comm. from the people of Kaut).

A trawler which first came to Long Island as an Australian or American military vessel, the 'Nania', was taken over by the Australian administration following the war and began making regular trips to Long Island in 1946-47 under the name 'Koro'. From this time contact with the outside world became both more regular and more frequent and, since the changes occurring during this postwar period are well remembered by many people alive today, a more coherent account can be presented than for the prewar period. Information on postwar European contact is therefore included in the following paper (Ball and Hughes 1982).

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LONG ISLAND, PAPUA NEW GUINEA — PEOPLE, RESOURCES AND CULTURE

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Records of the Australian Museum, 1982, **Volume 34 Number 10**, 463–525, Figures 1–7.

SUMMARY

Long Island provides, in microcosm and on a compressed time scale, an example of the sort of interaction between humans and their environment common to many Pacific islands. The current period of human occupancy of Long Island began sometime during the nineteenth century but until World War II the island remained isolated and population growth remained low. Since that time population growth has accelerated, contacts with the outside world have increased and the islanders are now beginning to enter a cash economy. The effects of these processes on the human society and its interactions with the environment are summarized. Major areas covered include human settlement and population growth, aspects of social organisation, wild resources and their use, outside influences affecting island society, the current status of the Long Island economy and possible future development options.

INTRODUCTION

This account of the people of Long Island, their resources and their culture is based upon published and unpublished documents and, except where otherwise acknowledged, our own observations and interviews. To the best of our knowledge, all statements herein were accurate as of mid-1979, when this account was completed. Most of the data were collected during nine visits devoted primarily to more specialized biological research and our total time on the island amounts to less than four months. All but three days of this was during October and November, that is, in the late dry season. Nevertheless, visits spread over nine years provided diachronic perspective and opportunities for checking the accuracy of earlier observations. We are impressed by the consistency (between informants, between locations and over time) of informants citing first hand observations and hearsay once removed. The general reliability of oral data in Papua New Guinea and techniques to enhance it are discussed elsewhere by Hughes (1977: 3-7). Our common language was New Guinea Pidgin and even the oldest residents had some command of it.

We italicize foreign words other than names which have been borrowed and published as English (e.g. Arop, Umboi). We are not linguists; we have rendered what we heard in the orthography used for New Guinea Pidgin by Mihalic (1971: 3-8). This is based on the NGP_1 dialect of the Madang area.

In many cases the European names on the old maps have already been replaced by local names but confusion is still possible because of historical lag and the large number of languages and dialects spoken in the area under discussion. Equivalents are:

Early Name	**English**	**New Guinea Pidgin**	**Long Island**
Dampier Is.	Karkar	—	—
Rich's Is.	Bagabag	—	—
Long Is.	Arop, Long Is.	Arop	Pono
Lottin Is.	Tolokiwa	Lokep	Lokep
Tupinier Is.	Sakar	Sakar	Orenge
Rook Is.	Umboi	Biksiasi or Siasi	Kowai (N.W. inland) Siasi (S&E coasts)
	Siassi Group	Siasi	Siasi
Kaiser Wilhelmsland	New Guinea	Niugini	Kowalmai

The locations of these and other localities referred to in the text are indicated in

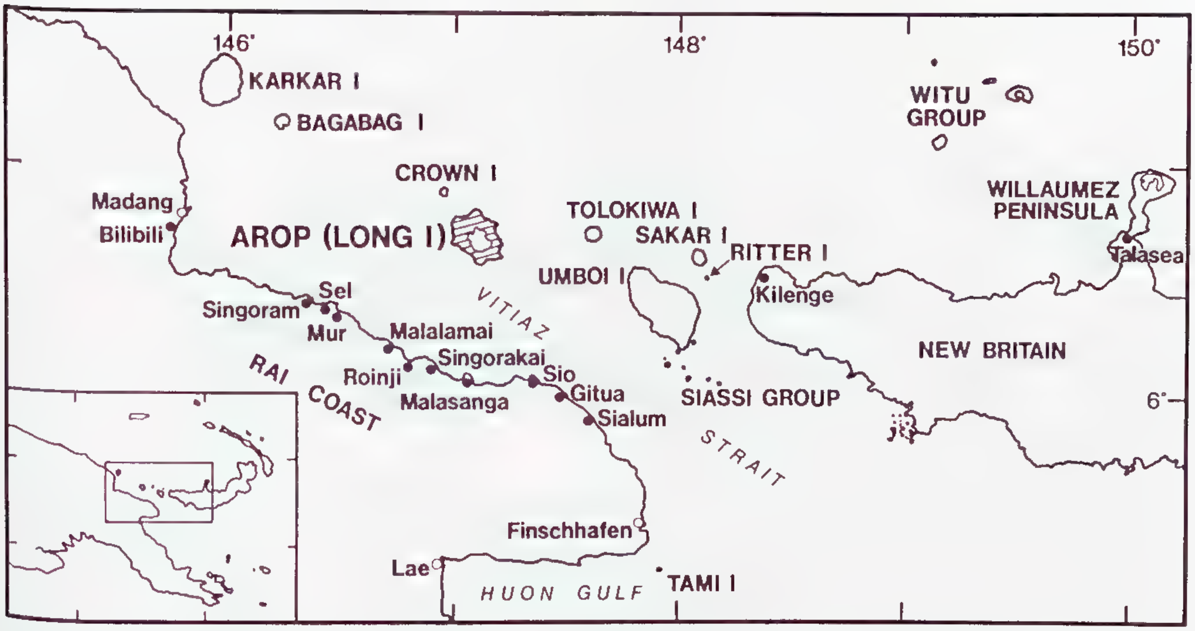

Fig. 1. Map of the area surrounding Long Island showing the position of localities mentioned in the text.

Figure 1. Figure 2 shows the principal geographic features of Long Island as well as present and former sites of human habitation.

Monetary values given in this paper are in the currency which was in use at the time. This was the Australian dollar until 1975 when Papua New Guinea established its own currency in which the *kina* (K) was the equivalent of the $A and the *toea* (t) was the equivalent of the cA. The *kina* was worth approximately $A1.25 in December, 1979.

1. Throughout this paper the following abbreviations will be used:

ADC	Assistant District Commissioner
ADO	Assistant District Officer
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DASF	Department of Agriculture, Stock and Fisheries
DC	District Commissioner
DO	District Officer
F	Father's name is
FF	Father's father's name is . . . (etc)
GNG	German New Guinea
MSL	Mean Sea Level
MTNG	Mandated Territory of New Guinea
NGP	New Guinea Pidgin
PNG	Papua New Guinea
PO	Patrol Officer

The external contacts reviewed in Ball (1982), while exposing the people of Long Island to ideas and goods from outside their culture, were infrequent enough to leave most traditional ways intact. Cash income (from contract plantation labour, other forms of away-from-home employment and from the export of shells and copra) and the exhortations of government and mission had relatively little influence compared with their effect on the more accessible settlements on the mainland. Since the war, the rate of economic and social change has increased under the influence of official policies but Long Island is still isolated and its cash economy remains small.

Examination of a proposal for making Long Island a conservation area as well as a concern with evaluating future economic options for the islanders took Hughes to the island for the first time. The nature of past and present changes and the complex equation to be solved by the Long Islanders and their advisors contemplating policy options are discussed here.

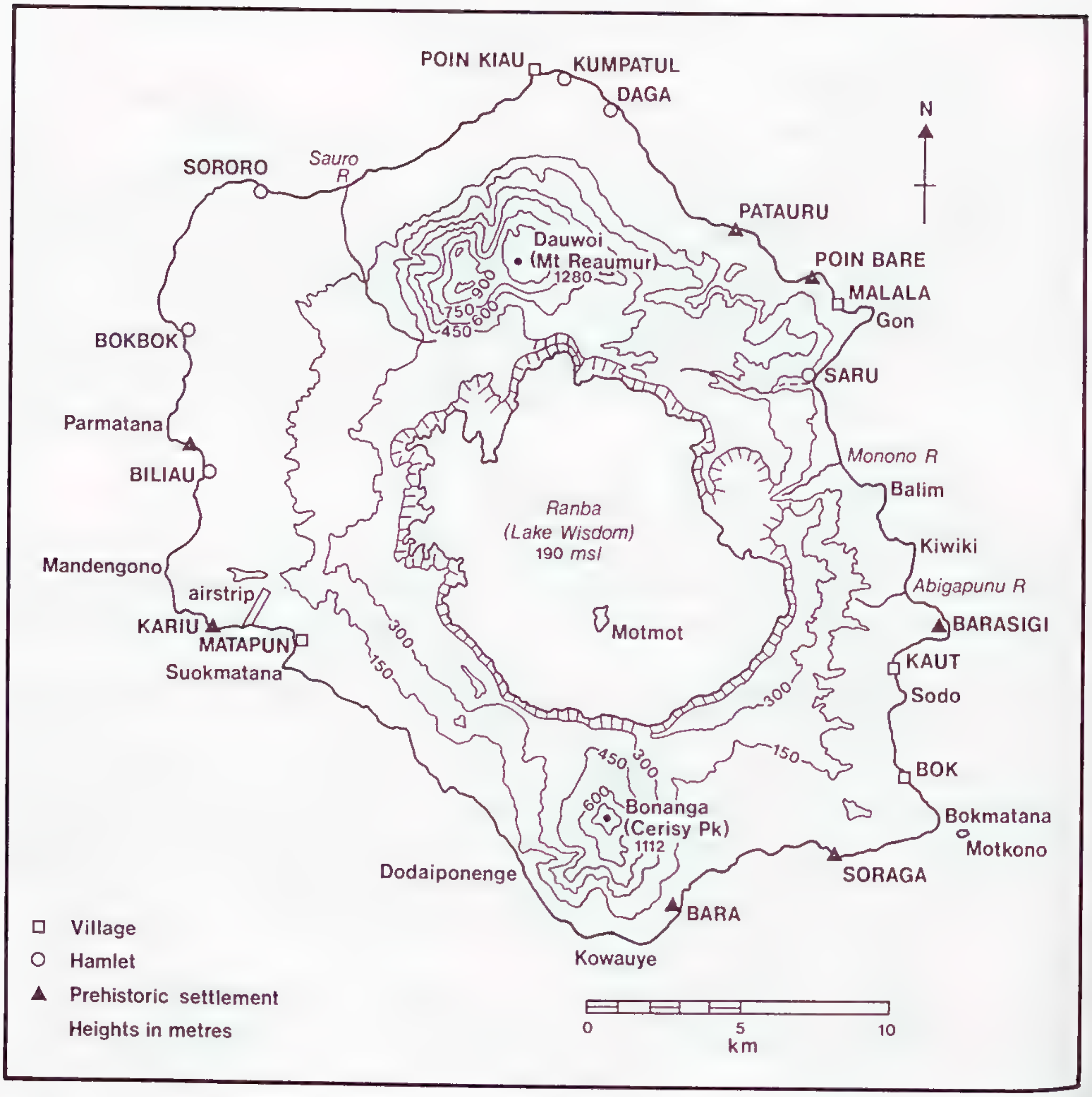

Fig. 2. Map of Long Island showing principal geographic features and the locations of past and present sites of human habitation.

We begin by surveying linguistic relationships and providing historical background largely through the medium of the people's own oral traditions and the observations of earlier visitors. We then give details of natural history and such ethnographic knowledge as we have been able to acquire, as part of a general presentation of resources and their utlization. Finally, we outline the development dilemma as we see it.

LANGUAGE

Long Islanders call their language (as well as their island) *Pono* and say that it is identical with that spoken on Tolokiwa and on the north-west tip of Umboi. Hooley (1976: 341) and McElhanon (1978, map II) call the language of Tolokiwa *Lukep*, after the local name for that island and say that it is also spoken on the north-west tip of Umboi. Hooley says nothing of Long Island, since his research area does not extend west of Morobe Province but McElhanon (1978, map II) includes it in the *Lukep* language area. Z'Graggen (1976: 287) does not appear to have visited Long Island and

his research area does not extend east of Madang Province. He calls the language *Arop* (after the common name for Long Island) and says that it is also spoken by some of the villagers in Mur and Sel, southeast of Saidor on the Rai Coast. He classifies it as one of a 'heterogeneous' Vitiazan Subfamily of languages in which he includes two other languages further along the coast to the southeast. The Vitiazan Subfamily is one of three which he distinguishes in a Siasi Family. This extends as far northwest as Karkar Island. The village of Mur exemplifies the complex antecedents of many of these coastal settlements. Ball visited it in 1978 and was told by DO W. R. Wilkinson that linguists of the Summer Institute of Linguistics had identified four separate dialects as being regularly spoken there. One informant at Mur, Ambalis (F: Wantung, FF: Anggei) recounted a legend (below) explaining some of the linguistic and social relationships between Mur and Long Island. His term for the Long Island language was *Pano*.

Linguistic relationships in the area are currently being investigated by P. C. Lincoln, who argues in an unpublished 1976 manuscript that Hooley's Malasanga language from the north coast of the Huon Peninsula is the same as Z'Graggen's *Arop* as spoken at Sel, and cites a Tolokiwan informant's statement that his own speech and that of Long Island and of Barim on Umboi are dialects of the language spoken in these mainland villages. However, McElhanon (1978, 4, map II) says that Malasanga village speaks the *Barim* language, not *Lukep* (*Arop*). Lincoln concludes that all these people 'in fairly recent times were a single speech community' and he proposes grouping them in a *Korap* Subfamily of languages rather than classing them as dialects of one language.

Interestingly for the general settlement history of the area, Lincoln maintains that another member of Z'Graggen's Vitiazan Subfamily forms part of a new Subfamily which includes some languages of the Huon Peninsula north coast, one of the Siassi Islands and some languages of West New Britain. McElhanon (1978: 2) makes the same connection, pointing out that Z'Graggen's Vitiazan Subfamily is the same as Chowning's (1976: 368-9) Bariai Family in West New Britain. Long Islanders themselves regard the speech of a number of settlements on the Rai Coast east of Saidor as closely related but not identical to their own. Nauna of Matapun told Ball that the language of Mur, Sel, Singorakai, Malasanga and Kiari was 'somewhat altered' from his own. Jared Diamond (pers. comm.) was told on Umboi that because of fighting, some of the pre-eruption inhabitants of Long Island had fled to Mantagen on north-west Umboi, and from there to Barim on Umboi's west coast. He was told that they had been on Umboi for at least five generations, for which a genealogy was remembered, and an unknown number of generations before that. At Sio, on the mainland, some villages include an Arop refugee among their ancestors, and the genealogies suggest that he arrived during the eighteenth century (T. G. Harding, pers. comm.).

It is clear that much more work is needed and that a linguist must visit Long Island. At present, the linguistic data tell us little more than could be gained from questioning a Long Islander: i.e. that his language is also spoken on Tolokiwa and the north-west tip of Umboi and is closely related to those spoken in a few coastal villages on the mainland.

Long Islanders' own terms for the nearer parts of their universe are as follows. Uninhabited Crown Island is part of their own domain, and is called *Kuru*. Their nearest inhabited neighbour, Tolokiwa, 40 km to the east, is known as *Lokep* (they explained that its European name is derived from the Tolai term for the island, *Lokewe*, prefixed by the Tolai honorific *To*). Inland Umboi they call *Kowai* and the southern and eastern coasts are included in the term *Siasi*. Sakar is called *Orenge*. The mainland of New Guinea is *Kowalmai*, which includes all that part of the coast to which they normally relate, from east of Sio along the Rai Coast, around Astrolabe Bay

and north beyond Madang.

HISTORICAL TRADITIONS

Myths and egends concerning the pat history of Long Island and its population have been collected by many visitors and we were no exception. Most, like us, communicated through New Guinea Pidgin. Some of our material was tape-recorded and the translation checked but most was taken down in long-hand. As might be expected, different visitors heard different stories anddiffering versions of the same story and recorded them with varying degrees of care, but in general the discrepancies are small enough for us to discern common outlines of the people's beliefs about their past and about the fate of earlier inhabitants.

Long Island myths that are essentially cosmological and epistemological are held in common with the speakers of Austronesian languages on Karkar and Bagabag Islands, around Astrolabe Bay and along the Rai Coast (Lawrence 1964: 21-24) and, although we have no evidence of it, they are probably shared by Austronesian speakers on the islands to the east and south-east (Tolokiwa, Sakar, Umboi and the Siassi group) and on the north-east coast of the Huon Peninsula. Some coastal people of Astrolabe Bay who speak non-Austronesian languages have the same myths of creation but it seems possible that these have been borrowed since the European voyages of the nineteenth century (see, for example, Lawrence 1964: 21, 63-68). The attachment of cargo-cult beliefs to these myths may have increased their currency. Legends relating to the most recent cataclysmic eruption and possibly to earlier eruptions are told on Long Island but one would expect them to be held more strongly and fully on the mainland, where traditions say that most of the survivors found refuge. Lawrence (1964: 22) reports such a legend originating with the Yabob people near Madang. T. G. Harding heard a similar account at Sio (letter, 1974) and M. Mennis (1978, see below) has recorded stories near Madang that are connected with the Long Island catastrophe, but we ourselves have not been able to interview further on the mainland, nor have we found Long Island traditions recorded by others. There may well be times when migrants, anxious about land rights in their new home, will suppress earlier traditions.

In many of its versions the Kilibob-Manup myth (the spellings vary; it is a central traditional element in most of the cargo beliefs of the area) accounts for the creation of Long Island and its aboriginal inhabitants. The earliest record appears to have been made by Hoffmann, a missionary at Bogadjim, a non-Austronesian area. It was included in the reports of the Rheinische Missionary Society for 1897 as the story of Kelibob and Mandumba and an abbreviated version was published in the same year in the *Deutsche Kolonialzeitung* (10 (38) N.S.: 379-380). The relevant portion translates:

> Thereupon it was decided that the young man Mandumba should also have an island. Therefore sand was also thrown out of the boat on the side where the outrigger was. There the island Mereju (Long Island) rose out of the water. But the young man Mandumba did not understand the speech of the people of Mereju. So his uncle took a breadfruit seed, roasted this in the fire, and threw it, red-hot, down the throat of Mandumba. The latter jerked his head back and shouted 'O Tenako' and could now understand and speak the language of Mereju.

A fuller version of the story collected by Hoffmann is given in Hagen (1899:281-283). There are many different versions of the Kilibob-Manup myth and they have been extensively discussed by Bodrogi (1953: 119-127; 1969: 187-188) and by Schmitz (1959: 46-49; 1960: 319-335). The most detailed of these versions from Biliau-Teter, Rai Coast, is given as follows by Bodrogi (1969: 187):

> But Manub sails forth to Mindira, Singa, and arrives at the beach of Biliau. He leaves there a man called Aisan who establishes a village in Ran-Tanggom. Manub proceeds to Teterei where he lands Madi. Kaison, the son of Madi, goes later to Malanggai, and a generation thereafter Bilei, the son of Kaison, proceeds to Galek. Manub continues his journey to Suit, Jaimas, Wap, Saui Dewang, Mur, Sel, Malamai, Bonga, and Yara. He quits the strand there and proceeds right to the Siassi Islands [which, according to Bodrogi and Schmitz, include Umboi, Long Island, Tolokiwa and Sakar]. It was from there that the other parts of the Rai Coast were subsequently occupied towards the West. While the descendants of Manub became more and more numerous, the line of Kilibob — reduced by him to three men — died out.

Other published versions of the myth have Kilibob himself moving south from Karkar and south-east along the Rai Coast, creating natural features, peopling the coast and equipping the humans with the necessities of life and the knowledge and skill to manage them. According to others, it was Manup (e.g. Bodrogi 1953: 126; Lawrence 1964: 22, 23). The direction of movement is opposite to that followed by migrating Austronesian speakers in general (Z'Graggen 1975: 40) and by speakers of the Siasi Family in particular (Z'Graggen 1976: 286). Lincoln, too, discerns an east to west movement of what he calls the Ngero Subfamily of Austronesian languages from West New Britain via the Siassi Islands to the mainland coast east of Saidor (1976: 3-6).

Riesenfeld (1950: 368-371, 671-673) argues from myths and legends that Long Island was first inhabited by immigrants from the west and southwest followed by a later wave of migrants from Umboi.

Schmitz's view of the migration as commencing rather than concluding at Karkar and proceeding east via Arop and Umboi to Siassi before travelling south and west along the mainland coast conforms only in its final stages with the interpretation of the linguists. Schmitz did not visit Long Island and our evidence shows that those who have lived there since the eruption came from the east, not from Karkar. In our opinion the linguistic evidence suggests that the pre-eruption population also spoke a language with close eastern affinities ('Vitiazan', 'Bariai', 'Korap') and that any earlier migration and diffusion to those areas from Karkar, as suggested by Schmitz and the Kilibob-Manup myth, must have occurred a very long time ago, if at all.

In another variant recounted to Ball in 1978 at the village of Mur by Ambalis (F: Wantung, FF: Anggei) the inhabitants of Long Island descended from Kilibob's mother. According to Ambalis an ancestor whose name had been forgotten, the younger of two brothers (cf. Kilibob and Manup), had left the Mur area (actually a nearby hill called Gila) after a family fight, and created Long Island and everything on it. Wounded by his older brother, and at the instigation of his mother, he built a canoe and loaded it with such things as soil, fire, domestic animals and useful plants of the garden and forest, and prepared to leave with his wife, mother and younger siblings. He took the leaf of a certain tree and held it wrapped around the steering oar, and set sail. The rush of water up the paddle ran over the leaf and took colour from it, turning the previously clear and translucent sea into its present dark green. After some time, he tipped a basket of soil over the side to form a reef and others to form Long Island itself and its mountains. They settled on the west coast, near the site of present day Matapun, and planted the seeds and slips brought with them. They spoke the language of Gila, but when a breadfruit seed on the fire exploded loudly from the heat, the brother created a new language, *Pano*.

On the mainland, the elder brother also decided to leave Gila, and loading a canoe with family, provisions and some of the Gila soil, sailed west to Bilibili, which was already inhabited. On the way, he damaged one of his eyes with a comb, and his descendants at Bilibili and Yabob often have a bad eye. The soil he brought is the clay from which the Bilibili people make pots. Ambalis added:

> This story is known on Long Island but we know it better. It is our tradition and it has come back to us, as the Pano language was later brought to Mur, Sel and Singorakai where some speak it. Customs and ceremonies from Gila, such as the Tumbuan dance, were taken to Long Island and later brought back by my grandfather Anggei and his wife, Neo.

At Sel, Tagoga (F: Sania) said that his grandfather, whose name was forgotten, had reached Sel from Long Island on a huge wave, accompanied by a woman, Danyeta. It was she who gave birth to Sania and a younger brother called Lapiu. Long before these events, their ancestors, a group of women with dogs for husbands, had lived at Sel. One of the women was abducted by a man from Singorakai (45 km to the east, and according to the informant and to Lincoln [1976: 2] speaking the same language) but his brother was killed by the dogs in an attempt to steal another woman. With the exception of one of the dog/husbands, the population of Sel was then destroyed in a concerted attack by Singorakai. The survivor seized fire from Tanoknok (a sea cave still to be seen and still sacred) in his mouth, leapt over the attackers and swam away to Long Island. This is why Long Island burns to this day, and has a large population of feral dogs. (The dog-ancestor's name was *Kamia,* founder of a superior breed). Like the village of Mur, Sel now comprises people from different places, including some from Long Island and some from the inland hills.

The only version of the Kilibob-Manup myth known to have been collected on Long Island itself was recorded by Ball in 1978 at Kaut and told by Milau (F: Bara). Hughes translates it as follows:

> Once two men lived at Mirku, one called Manup and one Kilibob. Manup was married and Kilibob single. One morning Manup [he meant Kilibob, see below] took his bow and arrows and went into the forest to hunt birds. He saw one and fired at it but the arrow passed over the top and he missed. It fell to the ground near his brother's wife. She picked it up, saw the pattern carved on it and hid it. Later, when her husband went out, she insisted that her brother-in-law tattoo this pattern upon her. He did so, placing it on her left groin. When she was climbing the steps to the house her husband saw the mark and asked how it got there. But she did not mention Kilibob; nevertheless he suspected his younger brother. The two brothers made a new garden and afterwards Manup tried to kill his younger brother, but he dodged the arrow and took shelter with his mother, who hid him, and he slept. The elder brother returned to his wife and said that he had killed his younger brother. But it was not true; he was hiding. Later his wife bore a child and all went to visit the grandparents. But they closed the door of the house so that the visitors wouldn't see the younger brother who was hiding there and tell the other brother who would then come and kill him. Later, when the old mother was away, children saw the young man asleep in the house. They told the elder brother where he was hiding. Manup got his bow and arrows ready and the younger brother also got his ready. They fought all though the forest until they came to Alexishafen. There Manup made a canoe and Kilibob made a ship. Manup sailed off toward the Sepik and Kilibob sailed to the Rai Coast. Everything that the ancestors had was in that ship and Kilibob distributed it there. As a result, all the Rai Coast and island people have these ancestral things and wear bark cloth, make drums, and ornament such things as bows and arrows. The ship continued south where it tied up at a wharf and the man finally disembarked.

After some time, Milau added a small part of the story that he had previously forgotten:

> When he tied up and finally disembarked he went to heaven and descended to the wharf in Sydney, and all the cargo descended there. The people there said 'these things are from Papua New Guinea'. But after that whatever became of it? [*Tasol behain i kamaut na i go olsem wanem?*].

According to Bamler (1911: 492) a legendary figure named Panku was blamed for 'the catastrophe which Long Island met in the landslide from Cerisy Peak'.

Another legend collected by Bamler (1911: 524-525) is:

> . . . that in earlier days Long Island had a connection with New Guinea and that the land went down in a stormy night. Of course the natives tell this story as a tale that an old woman had cursed the land, but which natural event would not bé explained by the native as supernatural interactions by evil spirits! In any case this sinking took place centuries ago.

ACCOUNTS OF THE ERUPTION

Folk traditions of ash falls resulting from volcanic eruptions are widespread in New Guinea and have been noted by a number of administrators, missionaries and research workers. Some of them on the mainland, especially in the area of Astrolabe Bay and the Rai Coast, almost certainly relate to the most recent cataclysm on Long Island. In 1887 Finschhafen experienced a rain of ash, which was thought to be from Ritter Island, northeast of Umboi (Hammer 1907: 18) which Chalmers (n.d. [1887]) had seen active in 1885 (not 1887 as given in Hammer). However, no ash falls were noted in Astrolabe Bay that year by either mission or Neu Guinea Compagnie personnel and the folk traditions of that area cannot be explained by the eruption of Ritter.

When Tagoga of Sel told Ball that his grandfather came from Long Island on a large wave he regarded this as happening at the same time as a Long Island woman (whom he called Galeki) is said to have escaped the eruption by fleeing to Tolokiwa. This latter event is a common component of the eruption stories about Long Island. On the other hand, if he had the generations right, his grandfather's arrival is more likely to be associated with the tsunami known to have resulted from the massive eruption of Ritter Island in 1888. On that occasion the Rai Coast was struck by a large wave (9 m high according to Taylor 1953: 1) which was 12 m (Parkinson 1907: 30) to 15 m (*Nachrichten über Kaiser Wilhelms-Land,* 1888: 77) high at the west end of New Britain and approximately 2 m at Blanche Bay (Rabaul) (Parkinson 1907: 29), while the reef at Finschhafen was exposed to a depth of ca. 2 m (*Nachrichten,* 1888: 77).

Destruction by large waves caused by local earth movements and volcanic eruptions is evidently not uncommon on the coast of north-east New Guinea; legends of such events are widespread, and they must refer to more than a single event. Mikloucho-Maclay, returning to Astrolabe Bay in June, 1876, saw the results of one such occurrence that had taken place since he left two and a half years previously. Houses near the beach had been carried away and the associated earthquakes had been felt on the coast and caused much damage inland. He learned that prior to his original visit in 1871 an entire village with all its inhabitants had been washed away by a huge wave which he estimated must have struck in about 1855 (Mikloucho-Maclay 1975: 236-237). Ambalis of Mur when a small boy (c. 1920-25) had himself seen such a wave break over the beach and he was carried up the hill by his mother to avoid it.

Mennis (1978) has carried out numerous interviews with Austronesian speakers from the vicinity of Madang, many of whom trace their ancestry to the island Yomba which supposedly once existed off Madang, perhaps on the site of what is now Hankow Reef. All of those interviewed agreed that Yomba blew up and disappeared before Arop erupted and many of the interviews give details of the latter eruption. A time of darkness associated with the eruption of Arop was reported as lasting for differing periods, the maximum being three days. The ash fall from Arop was heavy enough to ruin the gardens and cause a time of famine. Some reported that earthquakes and tidal waves were associated with the eruption, while others denied this.

A particularly interesting interview obtained by Mennis (1978: 25-28) was with Ber, headman of the Madib clan in Yabob village, and went as follows:

> My ancestors came from the Rai Coast — my papa was from there. Before that my ancestors escaped from Arop. Their names were Paspas and Galong. They came from Arop in canoes like the Bilibil *palaguts* and came ashore at Yaimai. They then went to Rewai near Malai. One of their wives was close to give birth.
>
> Paspas and Gaglong [spelling change in Mennis]) went inland. The others waited on the beach. They waited and waited and eventually one of them said: "You wait here I'll go and look for them. I think the bush men have killed them". He went up the mountain and found the two brothers — they had made a small house there from where they could see the smoke (of Arop?).
>
> Later Weir was born to this line — he was my ancestor. Weir was brought from the Rai Coast in a *bilum* (string bag) to Yabob.
>
> When Arop fired up the men saw it. The beaches were all filled with stones which we called *tadim*. When I was young there were still stones lying on the beaches. At the time of the eruption my ancestor said there was a time of darkness, earthquakes and tidal waves.

On the basis of the genealogies collected by Mennis the eruption of Arop would appear to have occurred 8-9 generations ago.

At Mur, Ambalis said that his mother had told him of 'dust' like crushed coral [*karanas*] falling from the sky in his ancestors' time in sufficient quantity to break the roofs of houses. His mother had heard that it was pale in colour and that it had covered the gardens and had hardened on the ground 'like cement'.

On Long Island itself, the first to record legends of a big eruption was apparently William Coultas, an ornithologist, who spent November, 1933 on the island. His unpublished journal states (1933-35: 268):

> According to native legend, Ahrup was at one time a large active volcano, much higher than Tolokiwa, and with a large population. Eventually an eruption occurred which blew the cone completely out of the centre of the island, throwing out hot stones and lava and killing the people, with the exception of one woman who escaped in a canoe to the mainland of New Guinea where her descendents are supposed to be living now.

Oral information about the eruption collected by a government officer after the Pacific War was cited by the geologist, G. A. Taylor (1953: 4, 5).

> Recent investigation by A.D.O. Parish suggests that the eruption was of comparitively recent origin as stories of the escape from Arop are still current among natives of the surrounding islands. It seems evident that some very alarming warning phenomena preceded this eruption as a considerable number of natives appear to have escaped from the island before the catastrophic eruption took place.
>
> Mr Parish believes that the Siassi island people originally come from Long Island, and has found, on the harsher parts of the neighbouring New Guinea coast, settlements of natives who are also evacuees. One group, he believes, settled near Lutheran Anchorage on northern Umboi but were subsequently wiped out by the 1888 eruption of Ritter Island.

In 1972, Hughes interviewed the oldest resident of Malala, an old man named Sili (F: Goreke, FF: Kaipongo, FFF: Korimi) who must have been born well before the turn of the century since his period of labour on German plantations before the first World War was well remembered. According to Sili, there was some warning before the eruption, and many of the inhabitants of Long Island and Crown Island (no prehistoric sites have so far been reported on Crown Island) fled to the mainland; their descendants now live at Graget, Bilibili and Yabob. The people of Siar, Graget, Bilibili and Yabob say that some of their ancestors came from Long Island when it erupted (L. Morauta, pers. comm., Mennis 1978).

There is a widespread tradition that the eruption was caused by sorcery arising from social conflict, a common pattern of causation in New Guinea history (see e.g. Hughes 1977: 204). At Bok, an informant aged about 60 years, Dakis (F: Kaidjip) related how a Rai Coast visitor named Girama had warned the people of Long Island to stop fighting. He himself was struck on the forehead by an arrow, but survived, binding it with a cordyline leaf. It was he who summoned fire and brimstone to punish the people of Long Island. At that time, added Dakis, the language of Long Island was *Karnai*, and their are still speakers of this language living on 'number two' Rai Coast. This refers to the portion each of Saidor (P. Lawrence, pers. comm.).

Glucksman and Ball collected two versions of the eruption legend. The first, said to have originated with the woman who found refuge on Tolokiwa, was from old Sili:

> A lone man in a canoe came to Bara [prehistoric site JCC — Egloff and Specht, 1982, Fig. 2] which is a point near Soraga. A big man from Bara was upset over family problems so he shot the stranger in the forehead with his bow and arrow. The stranger withdrew the arrow and told the big man 'you make a *singsing* and I'll come back to see you' The stranger returned with his father. While the father slept in the canoe the stranger put fire on top of the mountain. They then drifted along in the canoe, the son watching the island burn and the father still asleep. When they reached Saru [between Malala and the Arapos River] the father woke up and expressed dismay at the burning but the son said 'let it burn'.

Katip (F: Bara) of Kaut gave this account:

> A big man from Kurukuru Island (a real island in the Siassa group which blew up) [Ritter?] came to Bara, which is between Soraga and Matapun. He told the people not to bother making a *singsing* — that he would tell them a story, but they didn't listen to him. So he went back to Kurukuru and then he returned to Arop and shot a bow and arrow. After this he again returned to Kurukuru where he told the people to make a *singsing* following which he returned to Arop and started it on fire. The fire came up and finished Arop but a few people escaped. One woman escaped to Logep [Tolokiwa]

C. McKee and a Papua New Guinean colleague, P. Daimbari, of the Volcanological Observatory in Rabaul also collected this tradition in Bok and, together with Blong and Pain, they recorded versions from Matapun and Poin Kiau. The Bok account went:

> A visitor, Gramo [cf. Girama] came to Long Island, landing near Bonanga [Cerisy Peak] Talangi, who lived at Bara, was chased away to the Siassi Islands or nearby parts. All the people from Bara fought Gramo and he was speared through the head from temple to temple. He did not die, and a cordyline leaf was put through the hole. On leaving Long Island he told the people to have feasts and *singsings* now because he was going to return in three days to have his revenge. When he returned, strong winds sprang up and mosquitoes, ants, flies and locusts came in plagues. Tidal waves occurred and one big earthquake destroyed houses. But the people survived all these things, so Gramo went away to get his father. The two of them returned to Bara and Gramo threw a cane spear at Bonanga and an eruption started from a big mountain which existed in the middle of the island. From Bara they sailed around to Poin Kiau and then on to Kaut and during this time the father went to sleep. Gramo was supposed to wake his father to stop the eruption but he did not and everything on the island was destroyed.
>
> They returned home and stayed for three days before coming back to Long Island. On arrival at Long Island they found human bodies burned and stinking. So the father made dust come down to cover them. They then sailed home again.

The version from Matapun recorded by McKee added that Gramo had been accompanied by others and had come to steal women, and that this had led to the fight. His revenge had been accompanied by heavy rain and followed by a devastating bushfire. The mountain was called upon to cover the burned bodies, so the eruption began. It came from a large volcano that occupied the area where the caldera now is and it covered all the bodies, houses and trees with ash. Ash and stones fell on Tolokiwa, but without

causing damage. (Talangi and Bara were not mentioned, nor was the voyage around the island.)

Informants from Poin Kiau told much the same tale but added interesting details. Gramo warned the Long Island people of the coming earthquakes, tidal waves and storms. The eruption was brought about by sorcery performed by Gramo's father. It came from Cerisy Peak and was accompanied by very strong winds. On the voyage around the island, Gramo was supposed to wake his father before the eruption had done too much damage but failed to do so, and all were killed. When the two men returned three days later and called on the ground to cover the corpses dust fell from the sky (not from the mountain). Unlike the dust, the original ground was red-brown in colour. Many people had lived on Crown Island before the eruption but they travelled to the mainland and to Karkar Island to escape from the heat of the eruption. All their houses and gardens were burned but the island was not affected by the dust. Before the eruption there were two mountains about the same size as the present ones in the place now occupied by the caldera.

RESETTLEMENT

The eruption legends which conclude with the escape of a sole woman to Tolokiwa introduce the resettlement legends, and provide the new settlers with a legitimate connection with the previous population. In casual conversation about the past, some Long Islanders concur with the mainland traditions about survivors of the eruption travelling southwest to land on the mainland coast, and no-one actually disputes this. But legends told on Long Island by the present settlers record only the tradition of the survivor who travelled east to Tolokiwa.

Sili of Malala told Hughes that a woman escaped the destruction by swimming out to sea supported by a large wooden food vessel, and drifted to Tolokiwa. (Boat-shaped wooden dishes up to one and a half metres long are used on the island today). Her name was Tundun and she had lived at Poin Bare (prehistoric site JAB, Egloff and Specht 1982: Fig. 2) north of Malala. It was she who was claimed to have told Sili's great grandfather Korimi of the events surrounding her escape. Even on the most generous age estimates, that would have the eruption no earlier than 1780.

At Bok, McKee and Daimbari were told (pers. comm.):

> One young woman was able to escape from the eruption and paddled a canoe to Tolokiwa. She married there and had five children, two boys and three girls. One of the girls, Tauwalak, made a trip to Long Island landing at Kaut. On her return to Tolokiwa she married a man called Kaitip Kaulouru. They gathered a lot of people together and set out for Long Island to settle there. People from the Siassi and Umboi Islands followed the Tolokiwans in journeying to Long Island. Korimai from Umboi Island was one of these and he settled at Malala.

At Matapun they were told that the first arrival after the eruption was Korimi (they recorded it as Korimai) from Tolokiwa who lived at least three generations before the speaker, Botsai. Steam was still coming from the ground and there were stunted trees. The first settlement was at Malala. At Poin Kiau it was said that when Korimi arrived there was still smoke coming from all over the island and there was no grass. He sailed around the island and to Crown Island and found both uninhabited. So he returned to Tolokiwa to fetch his family, belongings and building materials. A second arrival, Samkoi, settled at Bok. Korimi asked him to meet to discuss ownership of the island. They met at Biliau and made a mark there to divide the island in two. Crown Island was taken by Korimi and the small rocky island Motkono (near Bok) was given to Samkoi.

It was Sili of Malala who maintained that the 'founder' Korimi was his great grandfather, and his account of the resettlement recorded by Hughes included circumstantial detail bearing directly on the question of legitimate rights to the land and its resources and the resources of the sea. Great grandfather Korimi and grandfather Kaiponggo were said to have been born at Sakar 'in the Siassi Islands' and to have moved from there to Tolokiwa. (His grandfather was already dead when Sili was born, so his contributions to Sili's oral tradition were acquired through his father Goreke. Goreke was born at Malala and died there before World War II).

At his birthplace, Sakar, Korimi was reputedly a notorious sorcerer and he was forced to flee to Tolokiwa with his family. Within a year or two he was driven from there, too, and sailed to Long Island with his young son, being the first to land since the eruption. He landed where Malala now stands and established that settlement. A cousin (clan brother) called Samkoi, also a powerful man on Sakar though no sorcerer, concerned about his long absence followed him to Tolokiwa and eventually to Long Island, his being the second canoe to land there since the eruption. He was accompanied by younger brothers. When he came ashore at Malala he was 'sent' south along the coast where he founded the settlement of Bok. All now living in the general area of Bok and Kaut were said to be descended from Samkoi and his brothers.

When Korimi and his party arrived the island was devoid of trees, and they used wood and food brought from Tolokiwa. By sheltering in holes, suggested Sili, a few goannas, bush-turkeys, bats and birds may have survived the eruption but pigs, dogs, cuscus and all other things were brought from Tolokiwa. Korimi revisited Tolokiwa and asked Tundun to name the natural features of Long Island, which she did. She died on Tolokiwa.

All at Malala and Poin Kiau were said to be descended from Korimi, who had two fertile and three barren wives. Genealogical statements from Sili in the presence of many witnesses were consistent and able to be extended laterally to siblings and cousins only as far back as the generation of his own father, Goreke, who was remembered as having had two wives, Patakeri (grandmother ? Takeri; cf. Tagere below) and Auri, the latter being the mother of Sili. Sili had two brothers, Sari and Sulungu. The descendants of Patakeri, too, were easily recited.

It is not unusual for a classificatory father, particularly a father's brother, to come to replace the biological father in a genealogy, and adoption is also a constant possibility, but the main interest here is the consistency of statements about the number of generations since the founding fathers, Korimi and Samkoi. All credited Korimi with the reputation of sorcerer and redoubtable fight leader and his legend is still appealed to as a sanction for political and economic matters. Sili said:

> Since Korimi's time, Malala territory extended as far south as Balim Point half way down the coast, but last year we shifted it north to the Monono River because the people of Kaut were short of land. Korimi controlled the west coast as far south as a small point south of Biliau, but now we have only to Paramatana north of Biliau. From there north, east and south around the coast to the Monono River is all controlled by Malala and its descendants.

The continuing relevance of this charter was shown recently when students from the National Fisheries School surveying the resources of Madang Province were told on Long Island that present fishing rights conformed with those established by the first settlers 'after the fire'. 'Orim' of Malala fished Crown Island and its reefs and the north coast of Long Island and down the west coast as far as Biliau, and the east coast as far as 'the Stone Island' (Malcolmson 1975, Section 1,3). To us, 'Stone Island' can only mean Motkono, the stack island lying off the south-east cape. If this is so and if it

was accurately reported, we suspect that the informant must have been a northerner, for Hughes was informed that the eastern boundary of fishing rights was the same as for land-use in general, formerly Balim headland and now the mouth of the Monono River. Furthermore, we have seen the residents of Bok and Kaut utilize the resources of the intertidal zone near their villages.

Franz Moeder, whose association with the island is longer than that of any other 'foreigner' and who has, at times, lived at Biliau, told Ball that he thought it likely that prior to the resettlement, people came from Tolokiwa and Siassi to catch turtles, and after it was seen that the island was revegetating one of them decided to live there.

In 1973, when Glucksman and Ball questioned Sili of Malala about the island's history, they had with them copies of photographs from the visit of the 'Südsee-Expedition' of 1909 (Reche 1954, Tafel 18; see Ball 1982) together with some names recorded during that visit. This created considerable interest and facilitated obtaining information. The Tagere of the German account was immediately recognized by Sili as an important woman of the period. He described her arrival on the island as follows:

> A second canoe containing Tagere and her husband Mariop went first to Bok. However, there was some sort of trouble [sorcery] there and they moved on to Soraga [apparently the Sora of the Germans] which was on the south side of the island between the present villages of Bok and Matapun. These first two parties had an agreement that if either was destroyed the other would return to Barim [on western Umboi] to let the people there know what had happened.

Botsai of Matapun informed Ball that Tagere had come from Siassi (Umboi). He thought Yapa was her husband, but after being asked about Mariop he said that the latter had indeed been her husband.

Aiyile, the village chief 'Aijile' in the German reports of 1909, was said to be the oldest son of Mariop and Tagere, so it is likely that Mariop's omission from the German record was because he had died. As Hannemann noted in a closely related culture at Madang (1949: 16) the talented wife of an influential man had prestige, especially after his death.

POPULATION GROWTH

Dampier (1729, 1939 edition: 218-219) saw one canoe put out towards him from Crown Island but no sign of smoke from fires on either island and therefore concluded that the islands were not densely inhabited. Dumont D'Urville (1832: 543-544) saw no sign of inhabitants in 1827 although he sailed along the north coast within two miles of shore. However, his course apparently did not take him near Malala (see Ball 1982: Fig. 3). The Morrells (Morrell, B., 1832: 459; Morrell, A. 1833: 77) claim to have seen 'a few scattering huts' and 'a number of natives' on the north coast from a distance of less than a mile. They may have seen the first settlers, although the description does not seem to fit the time or nature of the pioneer settlement described in the oral traditions. Another possibility is that they saw visiting gatherers of turtles and turtle eggs or fowl eggs. Unfortunately, the Morrell's evidence is of dubious value because of the couple's general unreliability, as has been noted by Ball (1982), Hughes (1977: 27) and J. M. Diamond (pers. comm.). Otto Finsch, in contrast, is usually reliable and his observation of people and houses on the east coast in 1884 is the first certain documentation that Long Island once again was inhabited (Finsch 1885: 5).

These observations indicate that resettlement had taken place by 1884 but the oral traditions, if accepted at face value, allow some further deductions. The Germans noted that in 1909 Tagere was grey-haired, her husband was dead and her son was

already a chief, but that she was energetic and influential; she is likely to have been close to 50 years of age. If she were already married when she arrived with Mariop, as recounted by Sili, the earliest date for the 'second' canoe would have been about 1875. But the tradition could mean that she and Mariop arrived together as children and later married; this would allow the date of arrival to be at least ten years earlier.

Either interpretation is congruent with the genealogies of the descendants of the 'first' canoe. Sili's work history (detailed below) indicated that he was born before 1890. Even if he, his father and grandfather were all first-born children, an unlikely circumstance, grandfather Korimi must have been born by 1815. Reputedly a powerful sorcerer before leaving Sakar, he stayed for a time on Tolokiwa before proceeding to Long Island, so he was very probably more than 30 years of age by the time he landed.

Together, these traditions suggest that resettlement took place between about 1850 and 1875, a span of years consistent with the accounts of the division of resources, social events and sequence of village foundation as well as with the well-remembered and partially documented growth of population and spread of settlement which took place largely during the twentieth century.

The few observations surviving from the German colonial period refer to the population as sparse, and no estimate of numbers has been found earlier than 1928. That and subsequent population figures are given in Table 1. The fall between 1928 and 1932 may appear to reflect the demise of Soraga; unfortunately, the earliest figure is undoubtedly the roughest of estimates and all of the figures were probably estimates until after World War II. More detailed census data are available for the most recent period and these are given in Tables 2A and 2B.

Even taking into account the unreliability of earlier figures, the population of Long Island has risen from nothing to nearly a thousand in little more than a century, and in the past forty years it has quadrupled. Furthermore, the rate of growth since

TABLE 1. Long Island population summary.

Year	Malala	Bok	Poin Kiau	Kaut	Matapun	Total	Source
1928	—	—	—	—	—	300	1
1932	—	—	—	—	—	230	2
1940	77	—	—	—	—	232	3, 4
1945	100	223	—	—	—	323	4
1949	105	259	—	—	—	364	4
1954	—	—	—	—	—	397	4
1958	—	—	—	—	—	411	4
1972	109	216	88	127	156	696 (excludes absentees)	5
1973	214*(231)	245 (266)	—	137 (141)	130 (150)	726 (788)	Table 2A
1974	217*(247)	249 (267)	—	142 (145)	122 (152)	730 (811)	Table 2A
1978						876(964)	Table 2B

1. Australia, Prime Minister's Dept. 1937.
2. Great Britain, Hydrographic Office 1946.
3. Allied Geographical Section 1943.
4. Figures obtained from old patrol reports courtesy ADC R.B. Creagh, Saidor, 1973.
5. Owet 1972.

* includes Poin Kiau

(Figures in brackets include absentees)

TABLE 2A. Census 1973 and 1974. Sources: Creagh 1973; Spencer 1974.

Village	Date of Census	Totals (excluding absentees) Child (under 15 years) M	F	Adult M	F	Absentees (resident outside electorate) Child (under 15 years) M	F	Adult M	F	Total
Malala*	21.2.73	52	60	59	43	1	3	11	2	231
	21.2.74	66	64	45	42	5	6	15	4	247
Bok	20.2.73	67	72	49	57	—	—	18	3	266
	20.3.74	73	61	52	63	2	2	14	0	267
Kaut	20.2.73	40	33	32	32	—	—	4	—	141
	20.2.74	48	37	28	29	0	0	3	0	145
Matapun	19.2.73	28	31	38	33	4	4	8	4	150
	19.2.74	34	32	27	29	5	6	14	5	152
Total	1973	187	196	178	165	5	7	41	9	788
Total	1974	221	194	152	163	12	14	46	9	811

*includes Poin Kiau

TABLE 2B. Census 1978 (dates 9 to 26 January). Source: Apa 1978

Age	Resident M	Absentee M	Total M	Resident F	Absentee F	Total F	Total
0-5	120	14	134	105	9	114	248
6-17	165	8	173	148	4	152	325
18-45	134	31	165	121	19	140	305
46+	42	3	45	41	0	41	86
Totals	461	56	517	415	32	447	964

the war has increased. Mechanisms of population adjustment that may have existed in precolonial times are unlikely to apply now. These facts raise serious questions about the future of the presently abundant resources of Long Island and the people who depend upon them.

SETTLEMENT PATTERN

Like most other speakers of Austronesian languages in Melanesia, the people of Long Island live on the edge of the sea. Most food is produced within a kilometre of the water's edge and the same narrow strip supplies much wood and fibre. Permanent running fresh water did not affect the main choice of settlement sites and most locations drew fresh water from wells in the sandy soil behind the berm at the top on the beach, now largely superseded by deeper wells lined with galvanized iron and further from the sea.

Malala was without doubt the pioneer settlement, as its name recalls. Ball and Glucksman were told that Malala was an abbreviation for Malalagurunu, meaning 'original landing place'. Early in 1972, so Hughes was told, while some of the young men were digging holes for new house-posts at the southern end of the village, they found human bones and concluded to their surprise that they had found an old burial

ground. The old people confirmed that it had been a cemetery when they were young, and they said that it may date back to the time of Korimi.

Bok was founded soon after Malala. Some time later, but certainly by the first few years of the twentieth century, Soraga had begun as an offshoot from Bok, for by the time the German scientists visited it in 1909 it was a large village. Since Mariop and Tagere were believed to be among the earliest settlers and she was grey-haired in 1909, Soraga may well date from the 1880's. When Glucksman and Ball interviewed Sili in regard to the German visit, they were told firmly that at that time there were only these three villages, not five as said by the Germans. They did not recognize the settlement of 'Ow' (Ov) mentioned in the published account, though, since Soraga was reputed to be very large, they speculated that 'Ow' may have been part of it. All the people of Soraga were said to have died as a result of sorcery, and the village was abandoned. Later, the site was largely destroyed by a huge wave. Katip (F: Bara) also told Ball that sorcery had been the cause of the deaths and that they had occurred about the time he was born, which he estimated was in the late 1920's. In recent years, further sea erosion is said to have removed all trace of Soraga.

In 1933, at the time of Coultas' stay on the island, there were only two villages, Malala and Bok (Coultas 1933-35: 264). Kaut appears to have begun as a small hamlet in the late 1930's but in the early 1940's the compilers of the AGS survey thought it had been abandoned (1943: 128). Patrol reports as late as 1949 continued to refer to only two villages. The new village of Matapun on the west coast was begun in about 1950 by people from Bok, and they were joined by a few people with Long Island kinship or affinal connections from the mainland and from Umboi. The hamlet of Kaut appears to have been revived in the late 1950's or early 1960's; it was certainly inhabited by 1969 (Bailey 1969). Poin Kiau had been a site for the seasonal shelters of the people of Malala (mainly for collecting the eggs of brush turkeys and turtles) for some years before the first permanent houses were built there in the mid-1960's. In 1972, there were garden houses at Saru and they have occasionally been built at other isolated east coast garden areas. By 1973, there was a well-made house at Kowauye at the southern end of the island and the remains of another at nearby Bara. By then, too, the north-west coast had one or two scattered houses of varying degrees of permanence. Since 1973, the people of Long Island have continued to spread away from their original villages into hamlets, as will be discussed below.

None of the present settlements, even the isolated hamlets, is on the site of a known settlement of the former inhabitants, though temporary garden houses have been built from time to time not far from Poin Bare north of Malala and Bara on the south coast, and Franz Moeder's establishment is near another prior habitation site.

NATURAL RESOURCES

As with all communities of agriculturalists, arable land is the most vital resource of Long Island. It appears to be the only significant mineral resource, since it is said that there is no pottery clay on the island and no visitors have seen any. We have not heard of earth pigments on the island but Ball was told at Mur and Sel on the Rai coast that red earth pigment was received from Long Island in trade. It is possible that some red ochre is associated with lava from an earlier volcanic period or that the Rai coast informants were mistaken. No obsidian has been reported except in prehistoric sites and that is from Talasea, New Britain (Egloff and Specht 1982) and geologists say that the eruptive material is not of a kind to produce volcanic glass. Nothing is known of the stone tool technology that certainly existed prior to the acquisition of iron in early colonial times, but part of a discoid club head (made from a stone type that does not occur on Long Island) was found in 1972 near Kaut.

Lack of water seriously limits agricultural productivity. Rainfall is inadequate and unreliable, and permanent streams are few. The only ones of any length are the Sauro on the northwest and the Abigapunu and the Monono on the east coast (see Specht *et al.* 1982, Fig. 5B). The people say that the latter became a permanent stream only shortly before the war, and Taylor (1953: 3) was told the same in the 1950's. This may have occurred because the lake surface only then reached its present 190 m above sea level or because headward erosion by ephemeral east coast streams finally cut into lake-fed aquifers. The location of the river's headwater springs is recognizable on aerial photographs, and in 1978 McKee and Angus of Matapun visited them. When Hughes visited the mouth of the Monono late in the drought year of 1972 (there was said to have been no rain for eight months) he estimated the discharge as about 90 cusecs (2.5 m^3/s). A year later, following a year of 'normal' rainfall, Ball and Glucksman (1978: 458) calculated the discharge at 4.4 m^3/s. To the north, the Arapos River has a much smaller discharge (estimated to be 1.0m^3/s in November 1973 [Ball and Glucksman 1978: 458]) and fails to reach the sea, emerging from the ground to run for less than a kilometre before again disappearing into the porous soil. In the same size range are the Sauro River which runs for an unknown distance before entering the sea and, on the east coast south of the Monono, the Abigapunu. At several other places on the northern, western and southern coasts, very small creeks emerge from dry river beds close to the sea and flow into it, and at other places seepages are ponded by the sand berm. During the rainy season some of these break through to the sea. There is little doubt that the three main streams of the east coast are lake-fed by percolation through the porous pyroclastic beds and that the lake acts as an enormous reservoir of fresh water which maintains the small seepages even at the end of a prolonged drought.

In 1972, the dry season was so extreme that by October conditions were already serious enough for the district administration to initiate a drought survey by DASF officers. N. Owet (1972: 4) reported that some of the small streams normally used to keep taro planting materials alive in readiness for planting at the onset of the wet season had completely dried up. His observations underscore the importance of these small water-courses in the gardening strategy. While they do not influence patterns of residential settlement, they are important in the management of the scattered food gardens.

Ball and Glucksman (1978: 458) estimated the mean annual rainfall as about 2800 mm on the basis of records maintained on Umboi and on the mainland coast, as well as upon comments made by administration officers. Rainfall is greater on the mountain tops (where considerable moisture is also gained by condensation directly from clouds onto foliage) but the lowland forests receive less than the average and the coastal gardens less again. Several observers support our own impressions that the seasonal variation is greater on Long Island than on the mainland, mainly because the dry season is longer and drier, extending from April to November. The wet season rainfall is also reported to be less than on the mainland (D. Clifton-Bassett, pers. comm.). The AGS (1943) report says that in the dry season, the foliage of the trees had been known to wither and turn brown, 'leaves being stripped from the trees; bush fires would be possible' (1943: 128). In 1972, we observed leaf fall in the late dry season throughout the lowland forest up to the altitude of the crater rim at 400 m MSL, characteristic of deciduous and semi-deciduous trees in a monsoonal climate. However, the climate is not monsoonal: the winds during the wettest months (December to March) are variable, though winds from the north and northwest are said to be most frequent. In that season, thunderstorms are common (AGS 1943: 127). During the dry months, southeasterly winds dominate and are sometimes quite strong.

The soils developed on the young porous tephras are thin, coarse and highly permeable. Humus levels appear to be low, in keeping with the recent development of vegetation. According to the pedologist H. Haantjens (pers. comm.), one can expect soils developed on recent volcanic 'ash' to be excessively drained and low in humus but there is no reason why they should be deficient in mineral nutrients. However, if grain size is large, the availability to plants may be reduced. Our observations suggest that this could be a factor in some of the island's arable areas.

The 'over-drained' soils and low rainfall mean that it is not unusual for a prolonged dry season to become a serious drought, and even in 'normal' years, garden foods are often in short supply before the next rainy season has helped to produce the new season's crops. Fortunately, the island is well endowed with wild food sources. In contrast to much of New Guinea, these are dominated by high protein sources. Gathering, hunting and fishing in that order, contribute much to diet.

WILD RESOURCES — VEGETATION

No botanical survey of Long Island has been published, though botanists from the National Herbarium, Lae, have visited the island several times. An early botanical visitor, Evans, spent three days on the north-east coast in the 'autumn' of 1925 and made the following observations on the vegetation (Evans 1939: 43-44):

> The vegetation is quite peculiar and ecologically most interesting. Although the rainfall is probably at least 70 inches per annum, judging by the fact that these islands lie in a wet belt, yet owing to the porous nature of the soil, combined probably with the desiccating effect of the constant trade winds, there is very little undergrowth and a marked absence of epiphytes, tree ferns and similar undergrowth. The low plain at the north-east of the island was covered with a growth of trees all approximately of the same age and probably between thirty or forty years old. There was so little undergrowth that one could walk about quite freely between the trees, where, of course, in tropical forests in similar latitudes it is usually necessary to hack one's way through with a cutlass.
>
> . . . The commonest forest tree was *Barringtonia speciosa,* which was everywhere abundant. Another common tree was the false almond *(Terminalia catappa).* The seeds of both these species float readily and the beach was in fact covered with the characteristic fruits. Other common trees, which possibly also originated from water-borne seeds, were *Cassia sp.* (possibly *fistula*), *Thespesia populnea* and, in one spot only, a small group of *Pandanus.*
>
> . . . In addition to these trees which had evidently arrived by water, were certain species that had probably originated from seed conveyed by birds. These included *Ficus, Eugenia* and *Canarium.* The island so far as we could judge was uninhabited but it teemed with large purple fruit pigeons, responsible no doubt for the introduction of these species. There were also a few Megapodes . . . and how they had arrived on the island has always been a puzzle, as they prefer running to flying and do not appear to be strong on the wing or capable of sustained flight.

J. S. Womersley (pers. comm.) has mentioned *Terminalia microcarpa* and *Prosopis insularum* as being common and we have recognised *Calophyllum ?inophyllum, Albizia falcataria, Albizia ?procera* and the stinging tree *Laportea sp.*, the latter being common in garden regrowth. Long Island informants say that they have the wild nut trees which are called in NGP *alia (Inocarpus edulis), galip (Canarium salomonense)* and *talis (Terminalia catappa)* and the fruit known as *mon* which Mihalic (1971: 136) identifies as *Dracontomelon mangiferum* but which is not listed under that name by Powell (1976: 108-112). Describing these as 'wild' is reasonable in the sense that they have been indigenous to Melanesia for a very long time, but the presence on Long Island of all or some of these valuable food species may well be due to planting or

transplanting. Such trees are sometimes transplanted from forest to village elsewhere. Species known to be planted are mentioned below.

Evans' characterization of the dominant trees of the north-east plain as an even-aged forest probably between thirty and forty years old brings out a remarkable characteristic of the lowland vegetation which deserves botanical investigation. More than forty years after Evans' estimate, J. S. Womersley (letter) said that when compared with trees of the same species elsewhere in the region, those on Long Island appeared to be no more than 40-50 years old. This cannot be interpreted as a second cycle in a rapid developmental stage but indicates that the same trees continue to look as if they were 40-50 years old. The evidence suggests that soils and climate have combined to produce conditions of very slow growth, with sizes at maturity which are below those of other parts of the New Guinea lowlands. It is likely that some species present at this altitude elsewhere are absent from Long Island, perhaps as a result of conditions hostile to their establishment, and that some that have 'returned' have not become widely established. E. E. Henty of the National Herbarium, Lae, identified the trees *Drypetes* sp. *Saurauia* sp. and *Eurya acuminata* from specimens collected from near the summit of Mt Reaumur and the timber used for the radiocarbon date ANU-1125 from the pre-eruption forest was identified as *Neonauclea* sp. by the Forest Products Laboratory of CSIRO's Division of Applied Chemistry (letter, 1973).

In 1933 Coultas saw the forest as 'a thick shambles of secondary soft wood trees and scrub bush' which he attributed to the recency of the eruption (1933-5: 32) and today the dominance of trees like *Albizia* in areas that apparently have never been gardened continues to give the impression of a prolonged seral stage. Their presence some 250-350 years after the eruption casts further doubt on the age estimates and suggests that the effect is due to extreme seasonal aridity and very porous soils, and that most of the lowland forest may already be in a steady state. The strongly seasonal moisture regime, unusual in the humid tropics, suggests that these trees may repay investigation by those interested in establishing tropical dendrochronologies.

The above characteristics of the low altitude forest means that there are probably fewer valuable wood and fibre species than most New Guinean human communities have available. Compared with mainland forest, hardwoods seem to be deficient and palm species few. The suite of wild vegetable foods appears to be small, although Coultas noted the leaves of three kinds of *Ficus* being boiled and eaten with grated coconut (1933-5: 286) and wild yams (*Dioscorea* sp.) are a seasonally important starchy tuber. Hughes was told of a forest tree called locally *didigi* of which the small fruits and pith of the growing shoots are eaten. A tree with red fleshy fruits (NGP= *wail laulau)* thought to be either a *Eugenia* sp. or a *Garcinia* sp. was seen deep in the east-coast forest and there are undoubtedly a number of other trees and shrubs supplying wild fruits, nuts and edible leaves and shoots.

It is possible that some of the coconuts, breadfruit and sago on uninhabited Crown Island could have become established without the aid of humans, the first being cast ashore by waves and the other two being distributed by animals. Breadfruit is widely reported to be distributed by flying fox. In his many voyages in these waters over more than forty years, Franz Moeder has seen mats of vegetation (of the kind often reported off the mouths of the Sepik and Ramu Rivers) floating in the Bismarck Sea well to the southeast of Bagabag Island. Much of the vegetation is still living, and crocodiles, snakes and waterfowl have been seen on the rafts, which appear to be breaking up by the time they near Crown Island where some of the flotsam finally strands. Moeder thinks that this mechanism has played an important part in the recolonization of Crown Island and to a lesser extent Long Island. However, in view of

the short time scale we believe that most if not all of the valuable 'wild' food species on both Crown and Long Islands have been planted or transplanted. Hughes was told that sago was first made on Long Island in the 1960's from transplantings dating from just after the war. Suckers were said to have been brought from the Rai coast as well as from Crown Island and in recent times seedlings of breadfruit have been transferred from Crown to Long Island to supplement those already there. The presence of fruiting coconut palms on the lip of the crater southwest of Malala is evidence that earlier travellers in the forest, probably hunters, planned for future journeys, and relatively casual plantings like this continue today. The coconut trees which were described as standing near the present site of Matapun by a wartime Allied Geographical Section Terrain Study (1943: 128) are likely to have been planted by fishing parties visiting from the east coast or by sheltering canoe travellers, judging by the casual tree planting that we have seen elsewhere on the island.

Names of some wild fruits and nuts of economic significance, recorded by Ball, are listed in Table 3.

TABLE 3. Wild Fruits and Nuts.

Long Island	NGP	English	Botanical
hip	aila	Polynesian chestnut	*Inocarpus edulis*
kangar	galip	Canarium almond	*Canarium salomonense*
taili	talis	tropical almond	*Terminalia catappa*
anrang	marita	pandanus	*Pandanus* sp.
unruk	marita	pandanus	*Pandanus* sp.
rak	mon	—	*Dracontomelon mangiferum*

WILD ANIMALS — TERRESTRIAL

It seems possible that the same conditions that have produced an unusually open forest with relatively simple vertical structure and sparse understorey have permitted a larger population of ground-dwelling animals and birds than in the mainland rain forests. To the observer with some familiarity with Australian forest types in addition to New Guinea rain forest, the density of animal life is more reminiscent of sclerophyll forests than of rain forests (see, e.g. Guiler 1965: 36, 37). This characteristic, combined with a small human population (crude density about 2.7/km² land area), has meant that to date the people of Long Island have been very affluent in terms of protein sources. Many of these are in the forest. Long Island has fewer bird species and much higher total numbers than islands which are of comparable size but have a longer history of uninterrupted biotic development (Diamond 1974: 803-6). Other elements of the fauna seem to follow the same pattern, as might be expected on an island recolonized relatively recently.

Here we are primarily concerned with animals of significance to the human population. (For a more comprehensive list see Appendix 4 in Lindgren 1975). Of the terrestrial reptiles, the most important is the goanna *Varanus indicus* whose skin supplies the tympanum for hand drums (NGP = *kundu)*, formerly a valuable Long Island item of export. It is also a welcome addition to diet. Constrictor snakes, especially pythons, are popular items of diet in many New Guinean communities but only the boa *Candoia carinata* has so far been reported (from both Long and Crown Islands) and it is not known to be eaten. Of the forest-dwelling mammals only bats, the rats (if native) and the cuscus *Phalanger orientalis* would normally be regarded as wild; however the latter was reportedly introduced by man. *Phalanger* are present in

very large numbers, and children can collect several in an afternoon without difficulty. Captured phalangers are a common sight in villages, especially in the late dry season, bound to poles or in various stages of preparation for the evening meal. They are so plentiful and easy to catch that children will sometimes have private feasts at any time of the day wherever they happen to have roamed along the foreshore. An unfortunate development for forest conservation since the introduction of steel axes is the readiness with which tall trees are felled to capture phalangers when the climb might be difficult, a method never used when axes were made of stone. We have observed the same change of method applied to the gathering of forest fruits elsewhere in Papua New Guinea in areas rarely frequented. The fur, which is highly valued in the highlands of the mainland, is simply burned off the carcass on an open fire.

Both insect-eating and fruit-eating bats have been seen, including the large fruit bat *Pteropus* sp. It is a popular food item in many parts of New Guinea but we do not know if it is eaten on Long Island; other meats can be obtained with less effort.

Feral species include large numbers of pigs, *Sus scrofa,* a large dog population, *Canis familiaris* and some cats *Felis ?sylvestris.* Hughes saw a large ginger feral cat hunting near a megapode egg-ground in 1972 and was told that they were fairly common. There is little doubt that the domestic dog and feral dog populations overlap to some extent in terms of breeding, for young puppies caught in the forest are hand reared from time to time. Yet Moeder believed the feral dogs were of distinctive appearance, with the dark 'blue' tongue and palate said to mark descent from Chow-like breeds. Village dogs in general were nondescript, mostly with flop-ears and highly variable hair colour. When Hughes asked at Poin Kiau about the appearance of the feral dogs a handsome sandy-coloured prick-eared bitch was produced that had been caught in the wild as a pup. It resembled the *C. familiaris hallstromii* of the alpine grasslands of New Guinea.

Feral and domestic pigs form one breeding population, and only recently have some of the people taken to keeping boars. A white boar was said to have been obtained from the European who built the navigation light at Poin Kiau in 1970, and one or two others are said to have been obtained elsewhere. Young piglets captured in the forest are sometimes raised in the village, and in former times, this was a main source of domestic pigs, though the German expedition of 1909 noted a well-prepared farrowing pen (see Ball 1982).

Wild pigs are hunted with dogs, spears and bush-knives and are taken with ease. One or two shotguns were said to have made their appearance on the island during 1973 and 1974 (there were reputedly none in 1972) but it has since been agreed that the islanders will limit their use (PNG Post Courier, Oct. 28, 1977).

Hughes made a two-day journey through the forest in 1972 during which soil freshly overturned by rooting pigs was commonly seen. The party captured two pigs and saw six others. Both captures were made only with the aid of dogs and a bushknife. In the first, a large pig was bailed up by 'Wanlek', a dog of average size (some 40 cm to the shoulders) but with only three legs, helped by two very small dogs. While the pig's attention was held by the dogs, one man dispatched it with a bushknife. The second capture was that of a small boar held down by 'Wanlek' alone. Since there was already a surfeit of meat, one man held the animal while his brother docked its tail, earmarked and castrated it. As it was released (while the dog was held) the men remarked that the event would be told in the village and that whoever took the pig at a later date would be obliged to give them some of the meat. It was said that this was a common practice in exploiting the feral pig population. Coultas (1933-5: 266, 273) noted that bows and arrows and slings were also used in hunting and that some game was taken with rope snares.

Two species of birds are important protein sources; the indigenous wild brush turkey *Megapodius freycinet* and the feral domestic fowl *Gallus gallus,* which has plumage resembling the bantam and game-cock and a build somewhat between the two. Both species are mainly ground-dwelling, though they roost in trees and fly up to a lower limb when disturbed on the ground. Although the crowing of cocks is commonly heard in the forest these birds are seldom eaten. This forest strain is said to have interbred occasionally with the predominantly white domestic poultry. Coultas (1933-5: 282) was told that Leghorn-type fowls had been brought to the island from Umboi by a returning indentured labourer. Domestic fowls are an important food item in many parts of New Guinea but neither megapodes nor either of the fowl varieties appear to fill this role on Long Island, perhaps because of the abundance of other, more readily available, protein sources.

Coultas wrote that 'Gallus and Megapode were both nesting near the village and eggs were hunted every day and brought for sale in addition to those of the domesticated fowl'. (1933-5: 268). We did not see any eggs of the feral fowl but those of the megapode were regularly consumed. Feathers from the feral fowl are an important item of ornament.

In contrast to some parts of New Britain, the megapodes do not use geothermal heat to hatch their eggs, nor do they build vegetation mounds to produce compost heat. In at least ten places around the island (see Fig. 3) usually at the head of the beach or just behind it and where the absence of trees allows sufficient sunlight to reach the ground, the birds lay their eggs in hollows scratched out of the loose sandy soil and bury them before returning to the forest. The *munamgaulok* egg-ground is typical, occupying nearly a hectare mostly in the dry bed of an ephemeral stream where it spreads out and becomes braided behind the beach. Isolated patches of soil have been dug up for laying as much as 100 m on either side of the main cleared area. Incubation is by insolation and the dark grey tephra reaches a high temperature during the day. When not laying, the birds remain in the forest where they are present in large numbers. Hughes made six observations at close quarters in one day, two of them being of pairs of birds. In each case they flew only a short distance to a lower branch and would have been easy to take with bow and arrow. The fact that they are rarely if ever hunted emphasizes their place as egg-layers in the Long Island food strategy.

A useful food item rich in fats was noticed on one journey when a youth in the party extracted and ate a large number of longicorn larvae from a fallen tree. They were rejected by the young boys present.

AQUATIC SPECIES

Black Duck *Anas superciliosa* are common on the fresh water of Ranba (Lake Wisdom) and could be taken relatively easily from hides but they are not utilized by the people, who seldom visit the lake. There are no fish in the lake. Salt water crocodiles *Crocodylus porosus* also inhabit the lake but they are few in number (perhaps only one or two) and favour the remote north-western shore. Before World War II the lake itself appears to have been avoided. Coultas wrote (1933-35: 41):

> The local populace hold this body of water in great veneration. They believe it to be inhabited by a race of super-humans who will catch and devour any one caught near its edge. Years ago a pig hunter was lost somewhere in the mountains and it is the belief of these people that he was captured and eaten by the lake monsters.

Crocodiles are also sometimes seen on the shores of Long Island, particularly the north coast, although they are both smaller and less numerous than formerly. They

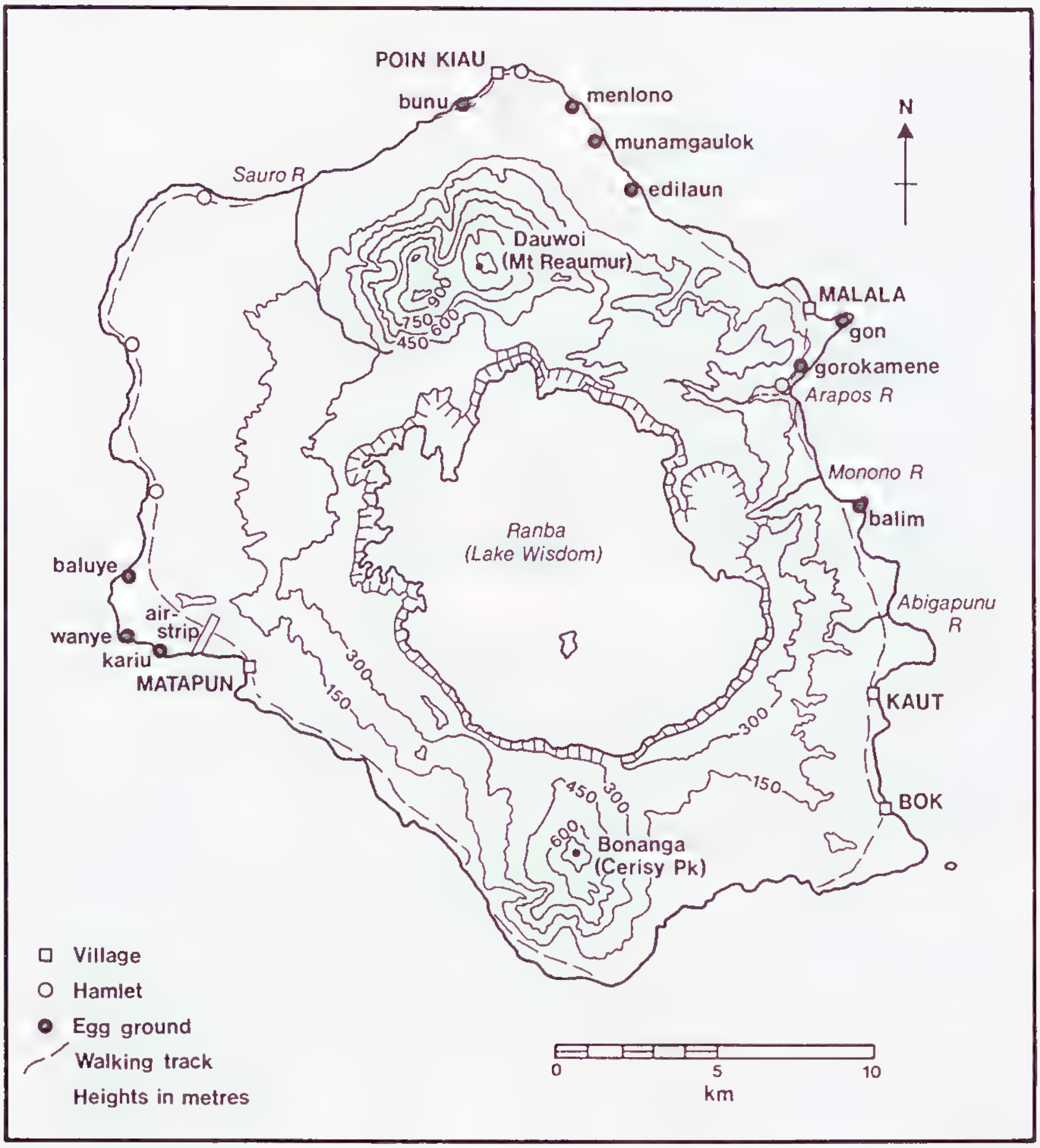

Fig. 3. Location of egg grounds and status of the walking track, November, 1978.

are said to be more common on Crown Island. In the past they have been shot for their skins by professional hunters from the mainland. The Long Islanders do not exploit crocodiles as a source of cash income and, in fact, they have requested Franz Moeder (pers. comm.) and others to shoot those crocodiles living near inhabited areas.

Crown Island has a well-developed barrier reef as well as fringing reefs; Long Island has fringing reefs only, and except on the southeast point, they are not extensive. Nevertheless, the sea is rich in reef fish and invertebrates. Although some of these marine resources are speared, netted or collected they are generally much less important on Long Island than in most New Guinea coastal settlements.

Three species of turtle supply the only important marine component of regular food intake, and that mainly in the form of eggs, of which there may be more than one hundred per nest. Turtles are rarely taken at sea but females are frequently captured on the beach when they come ashore to lay. It is said that formerly the animals were taken only for special occasions but now they can be a source of money

and the estimated number taken in 1973 was 329, all female (Lindgren 1975: 8). It was estimated by R. Wilson of DASF Wildlife Madang (pers. comm.) and Moeder (pers. comm.) that in 1976 about one thousand were killed. The Hawksbill *(Eretmochelys imbricata bissa)*, the Green Turtle *(Chelonia mydas)* and the rare Leathery Turtle *(Dermochelys coriacea)* all lay on Long Island's beaches, especially in the north. Nest sites are conspicuous and when dug no eggs are left to hatch. With the dispersed settlement pattern that has developed in recent years together with a great increase in foot traffic around the island's perimeter, fewer and fewer clutches of eggs are being allowed to hatch. Moeder (pers. comm.) stated that since the government school opened at Matapun in the 1950's children from as far away as Malala have been walking home at weekends and on the return trip they have collected quantities of eggs to eat during the week at school. Such a pattern of exploitation means that only occasionally will a nest survive undisturbed.

Territorial boundaries were described in the section entitled 'Resettlement'. Those who wish to collect or hunt on the territory of others must seek permission, but villagers whose beaches are not regularly visited by turtles (and that includes the large settlements of Bok and Matapun) tend to receive eggs by exchange or purchase.

A list of local names for animals of economic significance is given in Table 4.

TABLE 4. Animals, birds and fish.

Long Island	NGP	English	Zoological
ga	pik	pig	*Sus scrofa*
kiroro	kapul	cuscus	*Phalanger orientalis*
bianga	blakbokis	flying fox	*Pteropus* sp.
pon	trausel	turtle	Dermochelidae
kawadui		leathery turtle	*Dermochelys coriacea*
olol		hawksbill turtle	*Eretmochelys imbricata*
padodo		green turtle	*Chelonia mydas*
padodo rarasaua		a long variety	*Chelonia mydas*
padodo bartum		a short variety	*Chelonia mydas*
pon natun	kiau bilong trausel	turtle eggs	
man	pisin	bird	
tareke	kakaruk	rooster	
tataraga		feral chicken	*Gallus* sp.
malau		megapode	*Megapodius freycinet*
poryoi		black duck	*Anas superciliosa*
bal		grey imperial pigeon	*Ducula pistrinaria*
hi	pis	fish	
kruke	kindam	crayfish	*Panulirus* sp.
kese	kuka	crab	
tunu	maleo	marine eel	
adiwi	maleo	fresh water eel	
komobi	lalai	trochus	*Trochus niloticus*
komosi	talbum	green snail	*Turbo marmoratus*
gomokoko	kramsel	giant clam	*Tridacna gigas*

AGRICULTURE

Plants grown specifically for fibres were not investigated though one, a pandanus (NGP = *karuka*) was seen in a garden. Others, grown for ornament, include crotons and cordylines. In New Guinea tree crops sometimes assume particular significance in times of famine, and on Long Island, breadfruit *(Artocarpus altilis)* is often a very important source of carbohydrate during the late dry season, which on Long Island is a regular *taim hangri.* At that time, too, sago (made from the pith of the palm *Metroxylon sagu)* becomes desirable. Coconuts *(Cocos nucifera)* are plentiful all year round, and apart from being an important item in human diet, the flesh of the unripe nut is fed to dogs. There are mango trees *(Mangifera indica)* in some villages and also present are the malay apple *(Syzygium malaccense),* bananas *(Musa spp.),* a cultivated pandanus, pawpaw *(Carica papaya)* introduced citrus species (orange, lemon and grapefruit), the betel nut palm *(Areca catechu)* and its associated plant, the betel pepper *(Piper betle).* Table 5 summarizes the names of cultivated food trees and stimulants. Tobacco *(Nicotiana tabacum)* has been present in this part of New Guinea long enough to be a traditional crop and it is grown by all families. Angus (F: Botsai) told Ball that it was planted about March and harvested in November. Several informants said that their tobacco was the best in the district and was readily exported, and it seems likely that Long Island's combination of unusual seasonal aridity and porous soils may be as advantageous for this crop as it is disadvantageous for food growing.

TABLE 5. Names of cultivated food trees and stimulants.

Long Island	NGP	English	Botanical
kun	kapiak	breadfruit	*Artocarpus altilis*
mono	saksak	sago	*Metroxylon sagu*
piti	morota	sago leaf (for thatch)	
matuk	kokonas	coconut	*Cocos nucifera*
geng	popo	pawpaw	*Carica papaya*
pur	banana	banana	*Musa* spp.
hoi	mango	mango	*Mangifera indica*
pada	marita	pandanus	*Pandanus* sp.
bu	buai	betel nut	*Areca catechu*
ul	daka	betel pepper	*Piper betle*
kas	brus	tobacco	*Nicotiana tabacum*

Yams are the garden staple of Long Island, as they are in much of lowland New Guinea where there is a marked dry season. They are said to be of considerable ceremonial importance on Long Island (F. Moeder pers. comm.). If the growing season is a good one they are eaten all year round, the crop being stored in special yam houses. In November of the bad drought year 1972, yams were the most common garden plants, though in very poor condition, and only seed yams were left in most storehouses. There were at least three kind. *Dioscorea alata, D. esculenta* and probably *D. nummularia.* Taro *(Colocasia esculenta)* was also present, though not making any growth except where irrigated by running water. Most taro and chinese taro *(Xanthosoma sagittifolium)* seen at the time was held as planting stock beside permanent water (Fig. 5B). Gardens included some cassava *(Manihot esculenta)* usually around the edge, corn, rare sweet potato plants *(Ipomoea batatas)* and pumpkin. Three kinds of bean were present, including the winged bean, *Psophocarpus tetragonolobus,* and leafy green vegetables included *Hibiscus manihot, Amaranthus sp.* and others. Sugar cane *(Saccharum officinarum)* was

TABLE 6. Names of vegetables.

Long Island	NGP	English	Botanical
kaning	yam, mami	yam	*Dioscorea* spp.
mamui	mami	yam	*D. ?esculenta*
sirim	yam	yam	*D.* sp. or spp.
bus	taro	taro	*Colocasia esculenta*
galam	taro kongkong	chinese taro	*Xanthosoma sagittifolium*
serem bat	kaukau	sweet potato	*Ipomoea batatas*
kanikai	tapiok	cassava	*Manihot esculenta*
to	suka	sugarcane	*Saccharum officinarum*
tatiu	pitpit		*S. edule*
pongom	kukamba	cucumber	*Cucurbita* sp.
bede	kumu	leafy green vegetables	
bere	kumu	a leafy green vegetable	
gogo	kumu	a leafy green vegetable	
guru	kumu	a leafy green vegetable	
kios	kumu	a leafy green vegetable	

also present, as was the recently introduced pineapple *(Ananas comosus)*. Not seen but described by the people as commonly planted were *Saccharum edule* (NGP = *pitpit)*, of which the inflorescence is eaten, peanuts, cucumbers and watermelons. Onions are not grown although in the past they have been. Vegetables grown on Long Island, and their local names, are summarized in Table 6.

Coultas (1933-5: 30) mentioned a food plant called 'pan pan' but our informants did not recognise the term.

Bananas, taro and chinese taro are generally regarded as men's crops and the yams and sweet potatoes are specifically women's crops. Other gardening is a shared task, and Coultas observed how men, women and children all worked in the gardens (1933-5: 267).

A new garden is made largely by using a bushknife and fire, in marked contrast to the prominent use of tomahawks on much of the New Guinea mainland. A bushknife with a particularly heavy blade in Hughes' possession was greatly admired and men enquired about the source of supply. The largest trees are merely ringbarked, not felled, and the cleared trash is burned (Fig. 4A). Preparations are carried out late in the dry season when burning is easy and rains can be expected within two months. Because of feral pigs, gardens are sometimes fenced and then laid out internally often using sticks as markers (Fig. 4B). When it seems the rains are imminent (usually in October-November), planting begins; yams and taro being placed in small mounds (Fig. 4B). Sugarcane, corn and watermelons are also planted. Taro is also grown along running water which is frequently diverted to form irrigated taro gardens; the most extensive being along almost the entire course of the Arapos River.

There is a pronounced seasonal variation in the food supply. As mid-year approaches there is still considerable soil moisture and the gardens that were planted eight or nine months ago are in full production. The vegetable diet is rich and includes all the foods mentioned above. As the dry season progresses total garden production begins to fall, the variety decreases and yams, cassava and bananas supply most of the carbohydrate food. In late dry season yam supplies may already be low, bananas and sugar cane are bearing, a few families have irrigated taro and some have the introduced pineapple. Wild yams and breadfruit become important sources of carbohydrate and in general there is an increasing dependence on tree crops — starch from sago as well as the cultivated fruits and nuts like coconuts, pawpaw, mango, malay apples and wild fruits and nuts like the

Fig. 4. Shifting agriculture near the coast. **A.** A garden plot is cleared by felling, ring-barking, and burning. **B.** Ready for the planting of yams at the end of the dry season.

a

b

Fig. 5. Agriculture toward the end of the dry season. **A.** Last year's garden near the end of its life in October. **B.** Taro planting stock survives the dry season on a lagoon bank.

Fig. 6. Villages. **A.** Matapun, 1973. **B.** Newly constructed men's house at Bok, 1978. **C.** Poin Kiau, 1978.

nut pandanus. By the end of the dry season the wild yams and breadfruit crops are finished (in the drought year of 1972 they were exhausted by late October) and wild foods, especially animal foods, become very important sources of calories. This is the time when purchases of rice from the trade stores are heaviest and since this pattern is becoming usual the earning of cash income itself is becoming increasingly important. This pattern of food consumption continues until after the rains end in the new year, and the new crops begin to produce. Unless the season has been particularly good, there are often complaints of food shortage between December and May and even in good years preferred foods are always in short supply at this time.

Since the war, population growth (apparently aided by a lessening of social isolation in general) has led to a dispersal of gardens which is now being followed by a dispersal of settlement. Gardens have spread rapidly in the past ten years and there is an increasing tendency to form hamlets near the new gardens. The result has been a very rapid destruction of lowland vegetation, especially near the coast, and there will soon be no unaltered vegetation left in this zone, (Fig. 4A, 5A).

MATERIAL CULTURE

Houses built directly on the ground but more often raised on posts were noted in 1909 by the German expedition (see Ball 1982) and in 1933 Coultas (1933-5, 44) wrote that people 'build their homes well off the ground and include the storeroom in the house. A firewood storage is made in the roof of the structure . . .' Rectangular houses with gabled roofs, most of them with floors raised on posts, are still the typical house form (Fig. 6A, B, C). Most have a covered verandah protecting the doorway. Although there is no shortage of softwood timber for house construction, much of the planking used on the north and east coast seems to be driftwood. Ships' nameplates reflect the fact that timber from a number of wrecked ships has been incorporated into the walls of houses. Galvanized iron roofs are still in a small minority, most roofs being thatched with coconut fronds. Iron appears mainly on government buildings like the school, Franz Moeder's buildings, some village trade stores, and on copra dryers.

After houses, the largest structures built on Long Island are canoes, although nowadays they are smaller than the canoes formerly built for trading voyages. They have single outriggers with some decking between the booms. Harding (1967, 23) was told by mainland informants that the Long Island people 'constructed enormous dugouts without the addition of side planking' and they 'paddled rather than sailed their canoes across the Vitiaz Strait to Sio'. Lacking washstrakes they were 'said to have been easily swamped. If this happened, all but one or two of the dozen crewmen slipped into the water alongside the canoe while the others bailed it out'. According to Harding, sailing canoes were obtained in trade from the Siassi. These, according to Sili (F-Goreke) had sails woven from pandanus leaves. A sailing canoe complete with splash board and washstrakes was seen by Finsch at Long Island in 1885 (1888a: 188, 189). It had eight passengers. The mast head was ornamented with a triangle of carved birds and this is illustrated in Finsch 1888b (Plate VIII). Ball recently was shown a well-made model of a sailing canoe said to represent a style formerly known on Long Island. It had large washstrakes and splashboards. Hughes was told that five different tree species were used for canoe building.

Writing of clothing, Coultas (1933-5: 272) found that by 1933 most men had already abandoned the traditional breechclout made of bark cloth in favour of

> ugly calico 'lap laps' but the women still wear the pul-puls, made of the fine fibres of grass and woven onto a twisted rope. These grass skirts are all the uniform light tan color, about ten inches long in front by six inches wide, the thighs are entirely exposed and the skirt reaches to the back of the knees.

a

b

Fig. 7. The people and their culture. **A.** Dancers at opening of men's house at Poin Kiau, 1973. **B.** Hand drums (*kundu*) in different stages of construction.

The people of Malala told Ball that traditional women's skirts ceased to be worn by the time of World War II. Now all women wear cloth skirts as do most of the older men, though young men tend to wear short trousers. Even the fibre skirts and bustles made for ceremonial dances are now worn over cloth skirts (Fig. 7A).

Coultas continued his 1933 description of personal appearance:

> The hair is shaved off of the head, with exception of a broad V on the crown, and, on festive occasions, the shaved area was painted either red or blue; these powder paints having been brought in by Japanese fishermen are rapidly decreasing the use of lime and betel-nut juice for personal adornment.

Heads are no longer shaved, and store pigments have driven out the traditional mineral pigments, though vegetable dyes are still used.

Large boat-shaped food dishes *(tawiri)* for ceremonial occasions are imported from Siassi but smaller wooden dishes and large ornamented mortars and pestles *(roto bus* and *roto kutini* in the local language) are carved on Long Island, mainly from *Calophyllum*, and small ornamented betel-nut mortars *(roto bu)* are carved both for use and for export. Figures *(toltol)* of men *(tamoto)* and women *(garup)* up to 50 cm high are not uncommon (though they are said to be of no special significance), house tops are often decorated with carved fish or frigate birds and excellent hand-drums are made (Fig. 7B).

The large mortars and pestles are for food preparation, most often for producing taro puddings but also for crushing other farinaceous foods and mixing them with protein foods, fats and greens. Coultas (1933-5, 273) saw that 'puddings of grated tapioca [cassava], cocoanuts and bush-fowl eggs were moulded into huge balls the size of grape-fruit, wrapped in leaves, and baked in hot stones'. He also described 'soup of bananas and cocoanuts in benzine tins'. Since the war enamel bowls, plates and mugs have become common, as have metal spoons.

Coultas (1933-5: 272) noted that in 1933 cassowary plumes acquired by trade were used in ornamental dress and were very highly valued; these no longer appear to be used. When a new men's house was built at Poin Kiau in 1973, the opening was celebrated with a large feast and dance. Every participant wore full ceremonial regalia and the traditional elements in order of prominence were large carved painted head-dresses on the men, long pale fibre skirts and shoulder ornaments on the men, bustles on the women made of the same fibre, white kapok fibre stuck to poles above some head-dresses and in the hair of some of the women, and ornamental green leaves, mainly crotons. (See Fig. 7A.)

TRADE

The origins and destinations of Long Island's trade goods reflect the ecological diversity of the region and a considerable degree of product specialization. The only published work containing much information on Long Island trade is Harding's (1967) study of the specialist traders of the Siassi Islands, though Groves (1934: 47) noted that the people of Sio received betel mortars from Long Island. According to Harding (1967: 133, 134) the Siassi traded canoes and wooden bowls to the people of Long Island and received pigs and dogs in return. At the time of his field work in the early 1960's, Long Island drums (see Fig. 7B) purchased for cash (ten shillings to two pounds) and cloth were re-exported to New Britain (where a drum fetched a dog) and to the mainland (where a drum was worth a dogs' teeth headband). Trade with Rai Coast villages was mentioned above, and the people of the Madang area (Siar, Graget, Yabob and Bilibili) speak of trading connections with Long Island (L. Morauta, pers. comm.).

Exports from Long Island in former times included dogs' teeth and boars' tusks as well as the coloured feathers of feral fowl and tobacco. Tobacco continues to be exported to this day. The wooden bowls imported from the Siassi were the large boat-shaped *tawiri* mentioned earlier and some smaller round bowls came from Tolokiwa. Clay pots were imported from Sio, Bilibili and Yabob. Sago, cassowary plumes and bows and arrows were also imported, and although we have no direct statements about it, the general pattern of regional trade suggests that some net bags and supplies of bark cloth were probably imported from the mainland. Also, though it is no longer remembered, it is almost certain that the nineteenth century saw imports of obsidian (via intermediaries) from Talasea, New Britain, and stone axes from unknown sources. Although some iron had been distributed in the general area of the Vitiaz Strait during the nineteenth century (Hughes: 1977: 27-33) and according to Finsch (1888a: 189) glass beads and iron were known on Long Island by 1885, the latter being called 'gari', iron was still rare in early colonial times (e.g. Chalmers 1887: 148) and probably did not become common until the twentieth century.

Pigs are still being exported and in 1979 dogs were still being sent to Umboi (A. Ploeg, person. comm.). Pigs teeth are apparently no longer exported and the pottery imports have been replaced by metal (though an occasional Yabob pot purchased in Madang market can be seen). Sago is still imported. The long Siassi bowls are still received from time to time, and many can be seen in use in the villages. Once worth a pig (with bowl and pig matched in size), they now cost between K20 and K50. With care, such bowls will last five to ten years. New exports for cash (copra, shells and turtle meat) are discussed below. Past and present Long Island trade is summarized in Table 7.

Although they are not specialist traders like the sea-farers of Bilibili and the Siassi Islands (see Mikloucho-Maclay 1975, and Harding 1967), the people of Long Island appear to have carried many of their own exports and imports. Harding (1967: 23, 24) was told that like most of the people of the Rai Coast and Huon Peninsula, the people of Long Island lacked the sailing skills of the specialist traders and had canoes of inferior workmanship. Nevertheless, before the days of regular visits by boats belonging to the government, missions and private traders, Long Islanders made long canoe journeys to maintain the ties of kinship and marriage as well as to trade. Many east coast men are married to Tolokiwans and marriage links since the war have extended in many directions. Traders from Bilibili and Siassi also made voyages to Long Island and occasional visits were made by people of other islands.

TABLE 7. Items of trade.

Traditional		Modern	
Exports	**Imports**	**Exports**	**Imports**
pigs	long bowls	pigs	long bowls
dogs	canoes	dogs	sago
boars' tusks	small bowls	tobacco	rice
dogs' teeth	pots	betel mortars	manufactures like—
fowl feathers	bows	turtle meat	cloth
betel mortars	arrows	turtle eggs	clothing
tobacco	sago	copra	utensils
drums	cassowary plumes	trochus shells	bushknives
	? bark cloth	green snail shells	spades
	? net bags	wild fowl eggs	
	? obsidian		
	? stone axe blades		

Under the Australian administration, canoe voyages were discouraged throughout the territory, and Coultas noted in 1933 (274) that the long journeys were feared by the islanders; shortly before his visit a canoe with ten men and two women had been lost on the way to Umboi. Bara (F: Dagas) told Ball that before World War II he and three others had set out for Sio to buy sago, pottery and bows and arrows. The canoe sank and after a two-day swim the four landed at Gitua. Nevertheless, large canoes were used regularly up to the outbreak of the war, and according to Botsai, the last big voyage was just after the war when he and several others sailed to Siassi and Saidor. Since then, such trips have been strongly discouraged by the administration, and the incentive to make them has been reduced by the more frequent visits of administration, mission, and other ships. These frequent visits, combined with the advent of the trade stores, have tended to destroy the traditional trading networks.

CEREMONIES

Coultas (1933-35: 31, 270-272) was able to attend a long ceremony 'attended by the whole clan — some 100 strong' and made the following observations:

> Festivals or sing-sings in conjunction with the circumcision of the youths and their initiation into the tribe occurred during our visit. The ceremony began about four o'clock Sunday afternoon and ended some time during Wednesday. We were invited to attend and did so Sunday afternoon and twice in the evening.
>
> A platform similar to a small town bandstand had been erected in the circular clearing in the village and here sat eight youths each beating a beautifully carved wooden drum covered with the skin of the iguana. Three old men walked to and fro near the stand also beating drums. The two male dancers were the first to appear and were covered completely in grass capes. Layer upon layer of grass had been woven into a long skirt which reached from the waist to the ground. Another layer encircled the neck concealing the arms and reaching well down over the lower skirt. Long pointed masks, painted with glaring reds, blues and whites, covered the faces and extended well down the chests. The heads were covered with cassowary plumes, and from the crown waved a feather wand. The mounds of grass and feathers moved with remarkable rapidity, circling about the stand while the audience joined in a chant of rather solemn tone.
>
> After a short time the two grass dancers ran off to the bush and two young girls appeared. They had piled 'pul-puls' grass skirts one on top of the other to form huge bustles which moved up and down whenever they took a step. The breasts and upper arms were well covered with white beads and shell money 'tambu' and all wore boar's tusks. The two girls linked arms and kept step as they circled about the stand singing all the while and only pausing to work the knees in a bending up and down motion which caused the grass skirts to fly high in the air. As the evening progressed, the number of female dancers increased to eight, but never more than two men appeared at one time. Whether the same men danced all night, or whether it is customary for only two to appear at one time, I do not know. There was a certain beauty and rhythm about the dancing of the women, they never missed a step and were wonderfully accurate in timing the gyrations of the grass skirts, while the most remarkable part of the men's dancing was the quickness of their movements.

Coultas' description of the long pointed masks of the two male dancers suggests the painted conical bark-cloth-on-wicker *tubuan* masks of east New Britain (illustrated in Parkinson 1907: 573, 575) or the white and red painted carved masks of Tami (shown in Chauvet 1930: 96, Fig. 379). The latter have plumes on top, which according to Chauvet belong to bird of paradise but appear in the photograph to be cassowary. One of those illustrated by Chauvet has a prominent carved tuna tail, a common motif throughout the Siassi area and often seen on Long Island carvings. Coultas' description accords well with two *mundip* style masks photographed at Portne, west New Britain, by Dark (1974: 38, 71, Plate 68), for they are conical, each with a single wand covered with white chicken feathers protruding from the top. Another was

photographed at Birik, in the Mangap language area of south-east Umboi and another at Cape Gloucester (Dark 1974: Plate 73, Plate 75). Spectacular mask head-dresses like this appear to be no longer made on Long Island, for they have not been noted by any of the numerous post-war visitors.

In May 1973, a dance ceremony was held at Poin Kiau to celebrate the completion of a new young-men's house. Like the ceremony observed by Coultas, it was attended by most of the population of Malala and their kin from the hamlets near Poin Kiau. Singing and dancing lasted the better part of two days and continued through the night. Pigs were killed and huge puddings were mixed in the taro mortars and large fires were tended to heat the stones for earth-oven cooking.

However, the clothing and head-dresses were different to those seen by Coultas (Fig. 7A). Cloth skirts and short trousers were worn and these were quite unconcealed by the ornamental 'grass' skirts, bustles and shoulder coverings, which with cordyline and croton leaves, comprised most of the decoration. There were no masks, but the men wore painted boat-shaped head-dresses each crowned with a tall feathered shaft. There were no cassowary plumes. The majority of dancers were male, some drumming as they danced. However, the movements of a few women who took part, all unmarried, were much as described by Coultas, the leg movements being calculated to make the big fibre bustles bounce in sustained rhythm.

The head-dresses of the men (Fig. 7A) were similar to some of those illustrated by Parkinson (1907: Tafel 47) from the south coast of New Ireland, especially those which in his photograph have single tall 'wands' of white feathers crowning them. The Poin Kiau head-dresses resemble even more closely those of the *sia* dance photographed by Dark (1974: Plates 169-178) performed by the Kilenge of west New Britain. In contrast to the rather mysterious pair of concealed male dancers of the 1930's ceremony witnessed by Coultas (and to the *tubuan* 'Duk Duk' dancers), the other dance groups, including that at Poin Kiau, were dominated by men, with a few women participating. This is in contrast to the Rai Coast where women commonly participate in such dances (P. Lawrence, pers. comm.). The *sia* dancers told Dark (1974: 44) that they got the dance from the Siassi people and he thought it possible that it had originated on the Huon Peninsula. Museum collections and early photographs showed that it was known on the mainland in the nineteenth century and was established in west New Britain before World War II. Dark's observations of the Kilenge *sia* dance match ours at Poin Kiau — 'For while in other *singsings* most of the dancing is done by the women, the dancing is rather formalized and limiting to the performer. In *sia* there is great freedom for individual expression in many of the dances whether by the leader of a round . . . a solo dancer . . . or in group performances or duets' (Dark 1974: 44). At Poin Kiau in 1973, the *luluai* of Malala, drum in hand, danced most impressive solos on a number of occasions (Fig. 7A).

Opportune use was made of the occasion by preceding the celebration with a modern meeting concerned with such things as maintenance of the airstrip and school attendance, and it was notable that apart from a speech by a middle-aged *tultul*, the proceedings were dominated by young men, most of them literate in NGP and two of whom spoke English. They prepared a blackboard and chalk agenda, chaired the meeting and did most of the speaking.

SOCIAL ORGANIZATION

This has not been studied, though general statements occur in some patrol reports under the headings of anthropological, social and political notes. The group organization is predominantly patrilineal and the villages of Malala and Bok are essentially patriclan settlements, Poin Kiau being an offshoot of the former and Kaut

being settled from Bok. Land is held by the patriclan. Tables 1 and 2 (above) give an inflated impression of the size of these settlements, because of the custom of counting the residents of isolated hamlets in with their village relatives. All of the north-coast people are usually counted with Malala to total some 250 persons. In the case of Kaut, the census count of 145 persons also gives a false impression, for this is a relatively un-nucleated settlement lacking the well-developed central places of the founder villages. Matapun, with few more people than Kaut according to the census, has more of the characteristics of a village. It is made up of migrants from Bok and their relatives and friends from elsewhere.

The basic element of economic organization appears to be the nuclear family, with the families of brothers co-operating as an extended family for major social obligations and for interactions outside the village, including those connected with traditional trade and the cash economy. Leadership appears to be connected with such things as status and seniority within the formal kinship group, combined with economic achievement and personal qualities. Patrol officers observed that the *luluais* and *tultuls* appointed by government administrators, while respected locally, were not necessarily the most influential men in the village. One of the results of outside contact has been to produce new allegiances for some individuals which cut across traditional obligations to kin and affines; these are ties to the church or to certain cult leaders influenced by the cargo cult surrounding Yali of the Rai Coast (see especially Lawrence 1964). New economic linkages, as with copra buyers or the trader Moeder, are handled on an individual level when the sums involved are small, or within the traditional family structure when warranted. In the economic area, conflicts that may arise seem be be resolved by traditional mechanisms within the appropriate social group.

DISPUTES

Although the settling of disputes has been one of the roles of patrol officers, patrol reports for Long Island record few matters of conflict and those of any consequence have been over rights to land, especially for fishing and hunting. Traditional methods of dispute settlement appear to continue to cope with most of the contentions that arise. One syncretic method combining traditional and modern elements was observed by Coultas in 1933 (1933-35: 39-40):

> The two villages, the one we are living in and the one adjoining, assembled in the area behind our house and held a contest of kick cross, as they call it. It appears that a young man from the other village became personal with a young lady from our village. The elders here decided to bring shame to the young man and his people by trouncing them soundly at a game of soccer or kick cross. [NGP=*kik kros* = grudge game of soccer]. The game of kick cross may be translated as follows: A dispute, to a native, is a cross. In other words they are angry or cross with one another. If on the other hand, natives wish to play only and kick the ball back and forth between the goal posts, that is termed kick play. In kick cross there are no restrictions; any and everyone is entitled to kick the daylights out of the other, so long as hands are not used. The goal posts of soccer are set out but barely if ever, used, as the ball gets tromped on in the centre of the ring, kept within a small space, while dozens of legs and feet kick at any and every moving object.
>
> Our warriors kept at their game all day except for intervals of rest. By night time neither side had made a goal so they decided to continue on the morrow. [Next day] The brutal contest was discontinued by mutual consent of all parties. In all my life I have never seen such a fine collection of swollen feet and legs anywhere. The contestants can hardly walk and the Doctor Boy has at least half of his big toe missing from tearing it off on a rock.

The institution of *kik kros* has been widely reported in Papua New Guinea.

Sometime following World War II traditional attitudes toward territorial boundaries were disrupted and traditional mechanisms for avoiding disputes over boundaries, as well as settling such disputes when they arise, were handicapped by the government's arbitrary division of the island into four equal parts and the marking of these divisions with concrete posts. This action was said to have caused confusion and resentment (Creagh 1973: 9).

Land rights for residence, gardening, hunting and fishing are all recognized by custom and are inherited patrilineally (Creagh 1973: 9; Apa 1978). Difficulties that have sometimes arisen have occurred mainly in regard to cash-earning activities, as when Moeder employed divers from one village to work right around the island collecting shellfish. This was seen as violating traditional fishing rights, and villagers said that Moeder should employ only those with traditional rights to fish areas adjacent to their own villages (Malcolmson 1975, Section 1,5).

Rights to the resources of the reefs around Crown Island and possibly the coconuts on the strand of that island were said to have been a source of friction at one time between Malala and Matapun (Somers 1969: 1) and an earlier patrol had noted minor disputes over traditional economic obligations and affinal relationships (Bailey 1969:1) but in general this latter kind of disagreement did not appear to be brought to the notice of visiting patrol officers.

More recently there has been some minor conflict over church allegiance 'between the Malala/Poin Kiau group and the other villages' (Somers 1969: 2) which affected the location of the new mission school (Bailey 1969: 2). Malala residents were said to ridicule the people of Kaut and Bok for their cargo cult beliefs (Creagh 1973: 15).

OUTSIDE INFLUENCES

Until the advent of the Europeans, these were all within the traditional framework of social and economic connections and obligations, contacts being maintained with kin, affines and trading partners on other islands. Change began with the first trading contacts with European vessels, mainly exchanging foodstuffs for iron, and later with government and company ships, exchanging food, artifacts and eventually labour, for iron, cloth and other manufactures.

In early colonial times, the only profound new influences on individual Long Islanders were those experienced by indentured labourers, and until the time of World War II, periods spent off the island by a few individuals were probably the most important mechanism for broadening the islanders' views of the outside world. Several youths were recruited for work on German coconut plantations during the early years of this century, and possibly earlier. Sili of Malala said that the first time the Germans came to the island they sailed right around it, stopping at all three villages (Soraga, Bok and Malala) but that the people hid in the forest. Later, the ship returned to recruit labour and took people away, some by force. Angus (F: Botsai) of Matapun told Ball that one of the reasons why the Matapun area had not been used for a settlement earlier was because it was the island's only all-weather anchorage and people did not wish to settle where large ships could anchor.

Sili (F: Goreke), Bara (F: Dagas) and his brother, together with some others (including two men, one called Katip, who were accompanied by their wives) were placed aboard the vessel 'Mewa' ('Moewe'-photograph in Parkinson 1907: Plate 56). They were first taken to Madang (then Friedrich Wilhelmshafen) and later distributed to various plantations. Bara, who it was suggested was about 10 years at the time, was taken to Wuvulu Island where he remained for three years, and then to Maron in the

Hermit Group for two years, and from there to Witu for four years. From there, he said, the Germans returned him to Long Island. Sili said that he first worked at Maron Island, and tried to run away after three years. He hid on the island but was caught, flogged and gaoled. He escaped from the gaol, and a small pinnace took him to a steamship which took him to Kondambu near Kokopo, the German administrative centre in east New Britain. Another German vessel, the 'Siari' (the Neu Guinea Compagnie's ship 'Siar', see Rowley 1958: 8) took him to 'Arawe' where he worked on another plantation for a further three years. (Sili was probably referring to the Arawe Islands off the southern coast of west New Britain, rather than Arawa on Bougainville). After that, the steamer 'Kalili' took him to Umboi for a year after which he went to Rabaul. There he worked for 'Kiap Muli' handling native-grown copra. Some four years later there was talk of a big war and he was asked where he wanted to go. A warship took him to Umboi from where a Chinese trader returned him to Long Island.

We did not hear of labour recruitment under the Australian administration, but in the 1930's Lincoln Bell began to establish a plantation on Long Island near Bokbok and he employed four labourers to plant the coconuts. These included the experienced Sili and Bara, as well as Botsai, the father of informant Angus. After the plantation was laid out and planted, it was abandoned and most of the young palms died. During his stay at Malala in 1933, Coultas (1933-35: 31) was told that the only person from that village to have been away from the island in recent years was the medical orderly.

EVACUATION

Without doubt, the most dramatic event in the lives of the present generation was the total and prolonged evacuation of the island that took place in 1953. In May an eruption began in Lake Wisdom near the site that was active during World War II. Clouds of smoke were observed from as far away as Umboi and volcanologists thought that a very large eruption was possible, yet the inhabitants of Long Island were unaware that an eruption was taking place until visited by administration officers (Best 1956: 185).

The administration organized three vessels to shift the entire population in one day (Angus (F: Botsai) pers. comm.). Domestic animals that could be collected at short notice, mainly dogs and pigs, were also taken but many were left behind. Most of these joined the already large feral population inhabiting the forests.

The people were taken to Singoram on the Rai Coast and housed in a hospital building built during World War II. Food was provided by the government in conjunction with nearby villages. Whether it was because they expected the stay to be short or for other reasons, the refugees made no gardens at Singoram. Volcanic activity continued until January 1954 (Taylor 1956: 30) creating an island consisting of two craters joined by a ridge (Best 1956: 186). The evacuees spent nearly a year on the mainland before being returned to Long Island on the MV 'Koro' and a mission vessel; the last of them reached Long Island on 15 March, 1954 (R. B. Creagh, pers. comm.).

For many Long Islanders, the prolonged absence from their own small circumscribed island and the long suspension of the normal seasonal round of gardening and gathering must have been traumatic.

In 1968, 1973 and 1974 Motmot again erupted (D'Addario in Johnson, Taylor and Davies 172; Cooke *et al.* 1976), but on these occasions evacuation was not thought necessary.

MISSION INFLUENCE

The earliest known missionary contact was in 1925 when two Lutheran evangelists from Sio went to live on Long Island (T. G. Harding, pers. comm.). They lived at Bok

for many years, according to informant Samwel (F: Or). One of them, Moriu, erected a cement cross in that village, and it was only after he died that 'God's word was taken to Malala'. In the early 1940's two helpers from the Lutheran Mission on Umboi lived at Bok (AGS 1943: 6), presumably replacing the earlier Sio men, and after the war mission boats began to visit the island regularly.

By 1969 the Lutherans were still the only mission represented on Long Island, with a native pastor at Kaut and visits from a European missionary about four times a year. All village groups were then said to support the mission, especially Malala and Kaut (Bailey 1969: 3). But by 1972 the pastor or his successor had moved to Malala and that village was regarded as a mission stronghold, the weaker position of the mission in the other villages being due, it was thought, to a growth in support for cargo cult beliefs (Creagh 1973: 15). It appears to have been this polarization of opinion that led to the new bible school being located at Malala in 1972 and it may be significant in this context that when a rival mission, the Seventh Day Adventists, decided to commence activities on Long Island, they too selected a site (at Poin Kiau) within the general hegemony of Malala. A visiting patrol officer in early 1973 thought that each of the villages had a few residents loyal to the mission, even if only in single families, but that Malala people generally ridiculed the people of Kaut and Bok for their allegiance to the cargo cult. The pastor at Malala was said to speak out against the cult at every opportunity, an action which the officer thought in the long run would be counter-productive. However, he did not think that the situation would generate any serious conflict in village life (Creagh 1973: 15,16).

In 1972 Pastor Ulam of Malala accompanied Hughes on a journey to the lake. He said that almost all Bok and Kaut residents were adherents of the cargo cult associated with the Rai Coast leader Yali. They believed, said the pastor, that the day of judgement was so close that there was no time to do anything in the way of village improvement. Even worse, he added with contempt, they thought that when the last trumpet sounded 'piss and shit would turn into valuables'. His Malala companion, Tangi, was equally scathing, adding that in his village only one man and his wife subscribed to cargo cult beliefs.

CARGO CULT

Although documented evidence of cargo cult beliefs among the inhabitants of Long Island is all recent, it can be inferred from Lawrence's 1964 study of the cargo movement in the southern Madang Province that, because of their trading connections with the mainland, beliefs about the magical relationship between deities, the Europeans, and material wealth may well have been held by some Long Islanders since early colonial times (see e.g., Lawrence 1964: 63-85).

The latest large-scale manifestation of cargo cult beliefs in the area was centred around Yali of the Rai Coast between 1945 and his death in 1975. Some mainland people thought that the 1953 volcanic eruption on Long Island was caused by Yali invoking local deities to express his hatred of Europeans (Lawrence 1964: 268), although according to P. Lawrence (pers. comm.) this was not an accurate reflection of Yali's feelings towards them. Yali himself visited Long Island in 1968 (P. Lawrence pers. comm.).

The patrol officer who visited the island in mid-1969 (Bailey 1969: 2) reported:

> A rumour has been prevalent in the SAIDOR Sub-District since Good Friday that Independence (and, or) Self Government would be granted on either August 1st or 13th. During the June part of the patrol it came to the patrol's attention that this prophecy had reached Long Island via Madang, the source allegedly being YALI. The villagers of BOK are supposed to have built a 'HOUSE TAMBARAN' with effigies of their

> old heathern deities therein. The building was located in the bush and the people are supposed to have prayed to their gods for cargo to eventuate. The villagers vehemently denied such activities but I consider nevertheless that they were, and still are engaged in them. The people of this area freely admitted that they had heard the Independence talk. The Long Island version was basically the same as the one prevalent around the WARAI area in the MOT Census division but with the added refinement that YALI and his son KAMINA would first have to be crucified before anything was achieved. This refinement is not Long Island original thought but appears to have its origins in the BONGU area, as it could not be found in the SAIDOR believers credo.
>
> Overall the Long Islanders do not devote their lives to cultism but if such a rumour reached them, to use their own words "mipela itraim tasol, sapos samting ikamap gutpela, sapos nogat, maski". Such rumours brighten their normally dull lives.

Later that year another officer clearly thought that the cult had lost influence:

> There are still some adherents of Cargo Cultism, principally in the villages of Bok and Koet [Kaut]. The prime mover on Long Island appears to be one Salung of Matafuna [Matapun], who makes periodic forays to the Rai Coast to liaise with Yali Singina of Sor. He has little or no influence on the island, and the cult's followers would seem to adhere to it more from a form of insurance than from any real belief in its efficacy.

He added that although most of the people on the island claimed to be Lutherans, mission influence was weak, the people's attitude to the mission being lukewarm (Somers 1969: 3). Cargo beliefs were so common in the sub-district and district that the patrol officer's observations about their presence on Long Island went quite unremarked in the ensuing correspondence between his superior at Saidor and the District Commissioner in Madang.

One of Yali's campaign assistants, Dui, visited Long Island in July, 1972 accompanied by some of Yali's 'flower girls' and performed cult rituals (P. Lawrence, pers. comm.).

Late that year, the agricultural officer studying the drought criticised the people's small gardens, saying 'the people here don't plant big gardens as they expect more cargo from the sums of money they paid to some unauthorized persons (Cargo Cult)' (Owet 1972: 2).

By 1973 the cult was said to be strong in Bok and Kaut, with Matapun equally divided between those who favoured the official administration and the mission as against those who favoured the cargo cult. Malala and Poin Kiau were said to be strongly pro-administration (Creagh 1973: 2, 3). It is notable that the patrol officer saw the administration and mission as sharing similar aims and interests, a view apparently shared by the local people. The officer thought that those who supported the cult did so in the hope that it could bring benefits which the government could not bring. Nevertheless he thought that on the whole it was losing adherents, especially among the younger men, and that the solution to the cult 'problem' was to ignore it and attend to economic development (Creagh 1973: 3).

Yali died in September 1975, but in January 1978 PO Apa (1978, Situation Report 3) wrote that the cultist Dui was continuing to visit Long Island each year and that during his visit in 1977 he had been presented with two pigs. However, support for the cult was gradually decreasing and a cult house built at Matapun was rotting away together with the carvings and other cult symbols in it. The officer made a speech about the futility of expecting wealth from magical practices and extolled the virtues of hard work. Late that year the DO at Saidor also thought that cult activities were dying away (W. R. Wilkinson, pers. comm.), but on 12 March 1979 Luke Goreka, believed to be the Lutheran pastor of Bok village, alleged on the NBC programme "Contact" that the Yali cult was again active and that this activity was centred on Bok village (DO W. R. Wilkinson, letter 13.6.79).

WAGE LABOUR

Since World War II many absentees from Long Island have been employed as boats crew, and others have learned trades. In 1969, of the 19 adult males reported as working away from home, ten were employed on ships (three of them held 15 ton coxswain certificates) and four others were studying carpentry at Lae or Rabaul (Bailey 1969: 1, 3).

In 1972 a Malala man, Aluisa Gaima, was bosun of the government vessel 'Koro', and in 1976 had been promoted to captain of the MV 'Barena'. An Area Study in 1973 said that plantation labour was not recruited from Long Island but the patrol officer felt that absenteeism was nevertheless high (Creagh 1973, 4). Occupations of 41 skilled workers recorded at that time are given in Table 8. Few migrate permanently from Long Island, and Moeder could think of only six who had done so, but the growing list of tradesmen and professional workers in Table 8 suggests that more will do so in future.

TABLE 8. Trades of Long Island people in 1973 and 1974.

Village	Trade	1973	1974
Matapun	Boat Crew	5	8
	Clerk	1	1
	Storeman	2	2
Bok	Apprentice	2	2
	Boat Crew	8	5
	Carpenter		2
	Mechanic		1
	Ship's Master (20 tons)	1	1
	Storeman	1	1
	Trainee Patrol Officer	1	1
Kaut	Boat Crew	1	1
	Driver	1	1
	Heavy Equipment Operator	1	1
	Plantation Manager		1
Malala	Aid Post Orderly		1
	Baker		6
	Boat Crew		2
	Bosun	1	1
	Bricklayer	1	
	DASF Assistant	1	1
	Mechanic		1
	Teacher		1

Sources: Creagh 1973; Spencer 1974.

TRANSPORT

Between the wars, visits from administration and mission vessels were irregular, and the ships of traders like Bell and Moeder and the occasional visits of scientists like Coultas provided welcome additional contact with the wider world. Desire for a little more access to some of the benefits of the cash economy was expressed to Coultas when he prepared to leave the island in 1933. Those who had worked for him

regretted his departure and the end of their small income of goods and cash pointing out that Long Island was a good place to live and saying that they wanted 'someone to come and start a station so they could have a place to buy trade goods' (Coultas 1933-35: 274).

There were certainly outside contacts that went unrecorded during those years, and some of these were with commercial fishermen. Moeder (pers. comm.) recalled that during the 1930's a Japanese company brought Manus Islanders to Long Island to capture turtles, taking hundreds for oil and discarding the meat. Coultas, too, noted likely evidence of such contacts in the shape of a small girl with light yellow skin colour and Mongolian features (1933-35: 270).

The wartime visits of Australian, Japanese and American vessels are described by Ball (1982).

The government trawler, 'Koro', which provided the most important contact with the administrative centre of Madang for the past 30 years, first visited the island as the military vessel 'Nania' (Botsai, pers. comm.). The first official postwar patrol of the island was apparently carried out in 1947 by PO I. Griffin (R. B. Creagh, letter, 13.6.73). The monthly visits of the 'Koro' (replaced in the mid-1970's by the 'Barena') provided direct linkages with Madang and Saidor throughout the post-war period and visits of Lutheran mission ships (the 'Simbang' during the 1950's and since then, the 'Umboi') provided reliable connections with Umboi. Since 1978, the official administration link has been via the government work boat MV 'Kundiawa' stationed at Saidor. In 1979 the 'Kundiawa' was spending two weeks out of every four at Long Island (DO W. R. Wilkinson, letter 13.6.79). Moeder's 'Spray' (making frequent circumnavigations of the island during the peak copra season) and occasional visits from workboats owned by mainland villages have also been important connections for personal travel and for goods. The mobile trade-store of the 'Spray' was, for a number of years, the most important single source of manufactured goods for the villagers of Long Island, cash paid out in return for copra (and in earlier years, shells) often being spent before the recipient left the ship. Moeder is said to have now moved his commercial interests from the Long Island area to the Hermit and Ninigo Islands (M. Mennis, pers. comm.). In 1976 the people of Long Island and the Rai Coast Local Government Council purchased the MV 'Arop' to be based at Long Island and to be used for passengers and freight. Total control was handed over to the islanders in February 1978.

Most of the increasing traffic of official visitors (administrative and scientific) has been carried on government ships. However, in 1971, a small grassed airstrip (Category C) was built two kilometres west of Matapun and maintained adequately until 1975. A major factor in its construction was the desire to be able to evacuate sick or injured people quickly without the additional stress of a long sea journey. This enabled short-term visits from such officials as the government volcanologists and even brought a few tourist flights from Madang. Failure of the islanders to reach agreement about its maintenance led to its closure until 1978, when Bromley & Manton Pty. Ltd., of Mt. Hagen in the Western Highlands Province, employed ten labourers to clear it. Now re-opened as a private airstrip, they are using it for occasional flights from the highlands, and have built a small tourist lodge nearby (Apa 1978 part (e)).

HEALTH

The first relevant observations were made by the German Südsee-Expedition in 1909 in the village of Soraga. Thilenius (1927: 152, trans. V. B. Meyer-Rochow) wrote:

> Of the two houses on the ground one was inhabited by men, the other by 2 incurably

> ill people who could only move forward by crawling along and pushing forward with their skeleton-like legs and pulling forward their body with their hands while supporting themselves with their hands. Altogether there were 3 of these ill people, one man and two women. We had seen similar cases in several villages in Western Neu Pommern [New Britain]. Fulleborn presumes neuritic reasons. There was also one completely mentally retarded boy with an abnormal head formation and bent legs who we found squatting under a house. In general the population (which consisted of 5 men and 11 women and girls), which was of the New Guinea type, had remarkably good figures.

His colleague, Reche (1954: 90, trans. V. B. Meyer-Rochow) recorded the scene as:

> Remarkable were three incurably ill people which we found in one house. They were as thin as skeletons and could move forward only in a sitting position. They did this crawling, pulling with their hands and thus slowly moved themselves forward. One man and 2 women suffered from this disease the nature of which Fulleborn also could not determine since he hadn't seen it. He had remained aboard the ship to work through the results of the cruise. Similar cases we had seen rarely in other villages of West New Britain.

Coultas, who had worked elsewhere in the tropics, noted in 1933 (170) that on Long Island he saw no yaws or elephantiasis [filiariasis]. At that time the village of Malala had a medical orderly [NGP *dokta boi*] whose prime task, according to Coultas (1933-35: 31) did not appear to be the treatment of illness.

> The latter is given a number of bandages and a few tins of ointment with which he is supposed to go among his flock and administer treatment.
>
> In nine cases out of ten, the bandages are distributed among the men who wear the white muslin around one leg or an arm, or their head as an ornament. The red salve or ointment always finds its way to the faces and bodies of dancers during a festival. Anything as bright red as this ointment, is most valuable for personal adornment. It is sold by the Doctor Boy, at a profit to him.

Department of Health practice elsewhere in Papua New Guinea suggests that since World War II there must have been a number of visits to Long Island by their personnel, especially medical assistants, but we have found only one reference to them in district administration patrol reports (Creagh 1973: 2) and have not had opportunity to refer to health department records. That report noted only that since 1946 there had been frequent visits by representatives of the departments of the administrator, agriculture, and public health and that in the preceding few years there had been at least eight visits per year. In the early 1970's Ball sailed to Long Island aboard the 'Koro' with a dentist from Madang, who found that the children at the government school had almost perfect teeth. Comments on conditions of broad significance to general health are found in various government reports referring to such things as adequacy of food supply, housing quality and hygiene (especially latrines). The reports also note the existence and location of medical aid posts staffed by local medical orderlies.

A 1969 report noted the existence of aid posts at Matapun and Kaut (Bailey 1969: 1) and the accompanying area study reported a plague of bedbugs sufficiently severe to oblige most villagers to sleep on the beach. The people themselves blamed the DDT spray applied to their houses shortly before by a malaria control team (Bailey 1969: 2). The cure suggested was further insecticides (DC to ADC Saidor, 16.9.69).

A patrol in December of the same year reported that the two aid posts were efficiently maintained and operated and that they received the 'co-operation' of the villagers (Somers 1969: 3) and that health was generally good. The health service facilities at that time were regarded as adequate by the district administration (DC to ADC Saidor, 8.1.70, 2).

Near the end of the 1972 drought, the Rural Development Officer said that during the course of his survey of gardens and food supply, although there were no overt signs of malnutrition, complaints of stomach aches and headaches were received all around the island, mainly from children (Owet 1972: 5).

Mortality and morbidity figures do not appear to have been calculated, and the 1972 census patrol specifically noted that it was unable to obtain any information even on infant mortality. This patrol observed in passing that 'virtually all' houses had pit latrines and that an infant welfare sister from Umboi [presumably a mission sister] visted Long Island about every three months (Creagh 1973: 4, 13, 16). During the following year, a further census was conducted in the course of preparing an area study and eleven infants were said to have died of whooping cough (Spencer 1974: 2).

In 1978 an administration patrol (Apa 1978) complained that few latrines were actually in use, that the beach was being used instead and that in general hygiene was poor with flies breeding in the rubbish from humans and animals. Pigs should be fenced out of the villages and every household should have a toilet and rubbish pit, thought ADO G. Apa. But in general the health of the people was better than on the mainland. There were still two aid posts, but the one on the east coast had shifted to Bok. Earlier, the people had been told that the aid post orderlies would travel to other settlements from time to time, but they had not done so. They asked for a third aid post to be located near Poin Kiau.

While visiting Kaut during 1978, Ball was impressed by the high incidence of a fungus disease of the skin, thought to be *grile* (NGP for *Tinea imbricata*), not seen elsewhere on the island, but in general our observations on Long Island and elsewhere in Papua New Guinea over more than 10 years indicate that the Long Island communities enjoy a good level of health, at least in the dry season.

EDUCATION

Before World War II, Lutheran evangelists from Umboi probably gave some religious instruction on Long Island but the first administration school was not opened until the early 1950's. It was located at Kaut (F. Moeder, pers. comm.) but because it was not adequately supported by the local people it was moved to Matapun in 1965 where it has remained ever since (Bailey 1969: 1).

In 1969 it had 108 pupils drawn from all around the island but support from the local people was still a matter of contention, affecting attendance and building maintenance. It had four teachers teaching all six years of primary school, attendance in each grade being as shown in Table 9.

TABLE 9. Primary School Pupils, 1969.

Standard	*Male*	*Female*	*Total*
1	9	3	12
2	8	5	13
3	12	9	21
4	17	3	20
5	12	12	24
6	14	4	18
Totals	72	36	108

Source: Bailey 1969: 2.

In that year 17 percent of the population were said to be literate in NGP and two percent in English. All were said to be fluent speakers of NGP. Six past primary school pupils, all male, had continued to high school, though none at that stage had proceeded beyond year ten.

Early in 1969 the Lutheran mission was planning to open a small school for first year pupils but a dispute over its location had not yet been resolved by the villagers and mission (Bailey 1969: 1). By the end of the year, Malala was chosen as the site of the planned school which was to consist of a preparatory class and Standard 1. Since the government school was capable of accommodating all children on the island, the patrol officer thought that the Lutheran school was being built as a result of friction between the people of the northern settlements and those of the southern settlements.

At the time of the patrol's visit a seasonal shortage of carbohydrate foods for the school children was causing anxiety. The school gardens were nearly exhausted and it was hoped that the government would supply rice until the new gardens came into production in 1970 (Somers 1969: 1, 3).

The mission school commenced at Malala with a preparatory grade in 1970 (Bailey 1970: 1).

During the 1972 drought, school attendance dropped steadily from September onwards because of the food shortage (Owet 1972: 5) and by late February of the following year many of the children had not yet returned to school. Only four grades were being taught, grades three and four being absent. According to that patrol adult literacy rates were unchanged. Malala was the only village without a person literate in English; literacy in NGP was similar in all villages. Six students were absent at high school (five in Madang and one on Umboi) and six others were thought to have received some secondary education since they were employed at various district centres in occupations normally requiring some years at high school. Those literate in NGP were said to be avid readers of any printed material that they could obtain. According to the patrol officer, the mission school at Malala was essentially a bible school (Creagh 1973: 10, 11).

At the time of the next area study in February 1974, five school grades were being taught, standard three being still absent. Attendance, as a percentage of all children on the island, was less than in 1969 (Table 10). Part of the fall in enrolments was thought to be due to late arrival for the school year. Because the people of Matapun were no longer prepared to assist with making the school gardens, families from other villages were coming to help, and this, it was said, had delayed re-enrolments. Seven students were now absent at high school and seven were absent in occupations that normally required some high school education. (Spencer 1974: 9-10).

TABLE 10. Primary School Pupils, 1974.

Standard	*Male*	*Female*	*Total*
1	16	11	27
2	23	10	33
4	4	9	13
5	15	5	20
6	13	7	20
Totals	71	42	113

Source: Spencer 1974: 9.

In 1977 the Seventh Day Adventist Mission opened a school at Poin Kiau and attendance at the government school dropped dramatically. The fall was due in part to continued lack of material support from the residents of Matapun, the pupils from Kaut and Bok being said to be the ones mainly affected. The administration considered that if numbers remained low the school would have to be closed in order to better use the limited resources elsewhere (DO W. R. Wilkinson, pers. comm.).

The teachers at the government school have all been Papua New Guineans coming from diverse ethnic backgrounds. No Long Islander has yet received teacher training.

RADIOS

For many years radio receivers have been an important element of general education among the illiterate population of Papua New Guinea and they continue to have this role. News of social and political significance is disseminated largely by this means and it is an important medium for publicizing government policy. Radios are the first and main source of information dealing with events in the wider world and they are the islanders' main link with developments in the provincial centre, Madang, and the national capital, Port Moresby.

Radio ownership increased ninefold in the six years from 1969 to 1975; see Table 11. The rapid rise indicates a marked increase in the number of people exposed to outside ideas and information as well as indicating a transition in the place of the cash economy in household and village affairs. Radios are not only the first electrical goods to be bought in significant quantity by the people of Long Island, they are the first durable consumer goods other than axe heads, bushknives and simple cooking utensils. In part, the change reflects changes in the supply market; cheap radios running on ordinary torch batteries became available as part of the mass-market created by transistorization and miniaturization. Isolated Long Island is near the limits of the market area and the innovation reached there only recently. But the change also reflects the general increase in the role of cash within the domestic economy of the outlying areas of Madang Province.

In addition, in about 1970 two-way radio communication with Madang was made possible by locating an administration-owned radio transceiver at the government school near Matapun. When this was visited in 1978, it had been unserviceable for some time because of inability to obtain replacement batteries.

ENTERTAINMENT

In former times, the cultural impact of the outside world was mainly through the agency of returning labourers and travellers. Since radios have become popular and common, the Melanesian form of the string-band pop-music of the Pacific has reached Long Island and has been enthusiastically adopted by the young people. By 1978 each village had developed its own band which had come to play an important role in village life. Except for a few conservatives, villagers took pride in their local group, each named in the tradition of such bands throughout Oceania, Matapun with the 'Malangon Drifters', Malala with 'Kamogo Spakers' (*spak* = NGP, to be drunk), Kaut with 'Ragio Strangers' and Bok with 'Ramatin Brothers'. There was competition between the bands and the residents of each village were eager to hear tape recordings of the music of rival bands. The Malangon Drifters had won a competition in Saidor in 1977 and were hoping to participate in a bigger competition in Madang. By 1978 it appeared that membership of a string band was regarded as something worth striving for among the younger people and the old style of music seemed to be dying out.

TABLE 11. Ownership of radios.

	Bok	*Kaut*	*Matapun*	*Malala*	*Total*
1969	1	1	1	1	4
1973	3	5	3	9	20
1974	6	7	9	14	36

Source: Bailey 1969; Creagh 1973; Spencer 1974.

In October of that year Ball attended a dance at Matapun where the guitars were amplified through battery-powered radios or cassette recorders. Some 30 people were dancing with twice as many (of all ages) looking on. Some danced with members of their own sex, some with the opposite sex but there was no physical contact.

Attempts to arrange social activities in the modern style were made by some of the young people in 1976. In addition to sports like basketball and soccer, they organized social evenings. These were criticized by many of the older people as encouraging sexual freedom, and by 1978 most such efforts had collapsed. Some of the young people asked the Division of Social Development to send a representative to explain the importance of community social activity (Apa 1978, Situation Report 4). In October 1978 a large dance hall had just been completed in Bok (Fig. 6B) and was to be opened with a party in November. Many people from all parts of the island said that they planned to attend.

RETAIL STORES

In former times manufactures came to the island mainly with labourers and travellers returning from Madang, Saidor and Umboi, and this is still an important means of supplying durable goods. Later the mobile shop on the MV 'Spray' became the main source of factory-made goods and Moeder also maintained a store at his island base of Biliau. In 1969 an Australian named Bill Parkes settled at Matapun and opened a store but he left within a year.

Adequate supplies of store food to supplement garden produce during the period of low garden productivity sometimes becomes a cause for anxiety. Some is brought by returning travellers, but until 1976 most was imported by Moeder. Three items — rice, biscuits and sugar — made up most of his food sales. He sold large quantities of rice between November and February each year, and in drought years food was sold over a much longer period. Dry biscuits were also a popular line. Moeder said that he was surprised by the large amounts of sugar purchased, and when he enquired he was told that it was 'burnt' and added to water to make a drink.

Casual sales from occasional visiting vessels, either from ships stores or by private opportunists on board, also took place. In 1968 the captain of one vessel was said to have been making very profitable unlicensed sales of liquor (a/ADC Saidor to DC Madang 5.8.68). Even the Lutheran Mission vessel 'Umboi' was said to be making unlicensed sales of food and other goods, and in the opinion of the ADC, Saidor, this was to the disadvantage of the village trade stores (letter to DC Madang, 20.10.69).

In recent times, some village entrepreneurs have started small 'trade stores' selling a very small range of food and convenience goods like matches, importing their supplies in case lots directly from Madang and Saidor. By late 1969, there were six but they each had an annual turnover of less than $200 and were often out of stock (Bailey 1969: 1).

Three years later, towards the end of the severe drought of 1972, their role in the

seasonal food supply was examined by a Rural Development Officer. He reported that all four villages had from two to five licensed stores, depending on village size, and that they played an important role when garden food was short. There were also Moeder's Biliau store and a Parents and Citizens Association store associated with the Matapun school; their stocks were more reliable than those of the village stores which were sometimes exhausted for months at a time. However, three quarters of the island's population lived a day's walk away from the Biliau and Matapun stores and the villagers of the east coast asked the administration to ensure that Moeder's MV 'Spray' call regularly at every village to buy copra and sell rice (Owet 1972: 3).

In January and February 1973, before the new gardens were bearing, there were steady sales of rice and tinned fish from six village stores and from Moeder. The latter's food sales were then at the rate of $300 per week, most of it from the MV 'Spray' which at that time (at the peak of copra production) was making weekly tours of the island to trade (Creagh 1973: 14, 17).

The gap left by Moeder's subsequent move away from Long Island has now been filled by wholesale food imports on the islanders' own vessel, the 'Arop', for sale through village stores, the main items being rice, tinned fish, tinned meat, sugar, flour and biscuits.

UNPLANNED VISITORS AND OPPORTUNE WEALTH

With such a small cash economy, no modern manufacturing processes and no ready access to Madang town, windfalls have made significant contributions to incomes and property. It was noted in the section on material culture that driftwood and shipwrecks contributed materials to the largest Long Island structures, the houses. With no other supply of sawn planks, these chance receipts are highly valued. The large number of glass fishing floats to be seen in east coast villages testifies to the efficacy of the eastern shore as a collector of flotsam and one islander now owns an aluminium dinghy from the same source. In 1978 the people of Malala salvaged a 44 gallon drum of petrol from the sea, but the DO forbade them to sell it. Shipwrecks on the reefs of Long Island and Crown Island have provided substantial amounts of manufactured materials and even cash. Since the war, there have been several, three of which are recorded.

In 1958 the 'Nuguria' went aground south of Malala and became a total wreck, due, it is said, to the crew being drunk. The villagers salvaged 120 bolts of cloth from the hold, unrolled them and dried them in the sun, re-rolled them and built a shelter over them. They were paid 30 pounds for their trouble, a significant sum in the village at that time (letters, Subdistrict Office, Saidor).

In 1972, a sailing ship, the 'Ailana', was wrecked in the same general area, and a year later, the MV 'Matoko' became a total wreck on a reef between Long and Crown Islands. The 'Matoko's' owners heard that the Long Island people were pillaging parts of the vessel (it had been carrying only passengers) and their agent urged government officers to put a stop to this (letters, Subdistrict Office, Saidor).

During May 1973, when Motmot (the small volcanic island in the lake) was erupting, a light aircraft crashed into the lake when the engine failed. The three occupants swam to the shore where they were picked up by Army helicopter. The aircraft was later recovered from 25 m of water (PNG Post Courier, 4.5.73; J. Glucksman, pers. comm.).

Incidents such as this may provide significant wealth either in the form of salvage or in wages.

INCOME FROM OFFICIAL VISITORS

Labour in the service of visiting officials and scientists, mainly as carriers, but also as guides and collectors, has provided significant amounts of cash, and the frequency of such visits has increased greatly since World War II. Because of continuing volcanic activity from Motmot, volcanologists have been very frequent visitors. Ball estimates that during his seven periods of fieldwork on Long Island he paid out more than K700 in wages. Other income was earned from labouring from the installers of the navigation light on the north coast, and an Australian Army survey team working on the island in 1973 paid wages totalling $500 (Spencer 1974: 210). Additional significant income is earned from such visitors from the sale of fruit and vegetables.

REGULAR EMPLOYMENT

The only more regular sources of wage income on the island have been associated with commercial enterprises and with government development projects. None have continued for more than a few years.

Moeder's plantation and trading base at Biliau employed five Long Island men as labourers, largely for clearing and planting in 1973, and the patrol officer who noted the fact thought that when the plantation reached peak production it might employ from 10 to 15 men (Creagh 1973: 17). As small as it was, the employment opportunity provided by Moeder's enterprise was the only one that continued for a significant number of years. It is not known whether he retained some employees to maintain the plantation in his absence when he left in 1977.

During 1972 and 1973, $2000 was paid out of Rural Development Funds to local labourers, mainly from Matapun, to maintain the airstrip (Creagh 1973: 22), and when the strip was re-opened in January 1978 on the initiative of a private company, 10 labourers were employed, each receiving cash of K7.50 per week, after an initial issue to each man of one bush knife, one *sarip* (NGP = strip of hoop iron for grass cutting) and two files. The company also agreed to pay an annual rent of K100 for a site for a guest house and K12 monthly for its upkeep after it was built (Apa 1978, (e)).

COPRA, THE CASH CROP

The section above on trade listed all the items known to be exported from Long Island, some cultivated, some gathered from the sea and some manufactured. The traditional export items, tobacco and betel mortars, are still occasionally bartered or they can form part of a delayed gift-exchange, but most traffic is for cash.

Copra is the mainstay of the cash economy, although until very recently it was all sun-dried and did not command the best price. There is no interplanting of cocoa between the coconut palms, though in neighbouring areas, e.g. Karkar Island, this is common.

There have been a number of estimates and counts of palm numbers, that of trees planted before mid-1969 being given in Table 12.

The same study notes that in the succeeding three months further plantings took place, 508 at Matapun, 216 at Malala, 56 at Kaut and 804 at Bok.

The patrol officer estimated the island's potential production at 55 tonnes per annum, but said that much less than this was actually harvested, dried and sold. It was sold loose by weight, brought in to the purchaser by the *bilum* (NGP = traditional net bag) and at that time most was bought by the Lutheran mission vessel 'Umboi'. Marketing facilities were adequate, according to the patrol officer, and plans were in

TABLE 12. Coconut palms prior to June 1969.

Village	Immature	Mature	Total
Matapun	2913	1131	4044
Malala	2781	2738	5519
Kaut	2107	2073	4180
Bok	4430	4032	8462
	12231	9974	22205

Source: Bailey 1969: 4.

hand to station an agricultural extension worker on the island and build a series of heated copra driers (Bailey 1969: 5). The increased plantings for that year were attributed to the efforts of two extension workers in mid-year, and the official view was that the lethargy of the local people was the main obstacle to economic development (Bailey 1969: ADC Saidor to DC Madang, 3.9.69). The District Commissioner was of the opinion that without sustained extension work by DASF and constant encouragement by administration staff the ground already cleared for an additional 6000 coconut palms would revert to bush (DC Madang to Administrator, 16.9.69) and he urged the Saidor personnel to organize a new marketing system, each village to register with the Copra Marketing Board and sell directly to it (DC Madang to ADC Saidor, 16.9.69).

A patrol at the end of the year noted that little copra was being produced and that unlicensed copra buying by the mission boat had been stopped. Regular visits were needed to stimulate activity, it was said (Somers 1969: 2).

In 1970 'New Ireland' type copra driers were built in each village and resulted in the export of 'considerable quantities' of copra and a further increase in output was expected with the onset of the wet season (Bailey 1970: 2). During the early 1970's Moeder was the sole buyer of copra, his visits being weekly during the peak production period (Owet 1972: 3). Production was increased each year and Moeder was said to be buying about four tons per week during the 1972-73 wet season, a figure that the patrol officer thought could increase three-fold within 10 years (Creagh 1973:17). Moeder was paying 2.5 cents per pound of loose copra and 3 cents per pound bagged; most copra offered for sale was loose. At $56 per ton and 208 tons per year, the patrol officer estimated an annual income to the island of more than $11,000 (Creagh 1973: 21), which was some $65 to $70 a year per family. However, average weekly production during the year was probably below the wet-season peak.

Early in 1974 DASF staff counted only 9,380 coconut palms which was less than the figure given in the 1969 census for mature trees alone, and they estimated the production as about a quarter of the figure cited by Moeder. Another copra buyer, Peter Lam of Madang, was competing with Moeder, and both traders were then paying eight cents per pound for loose copra yielding an estimated gross income for the island of some $8,600. This was estimated to be about $80 per adult male (Spencer 1974: 20, 23) which is puzzling, since the same patrol officer recorded 152 resident adult males in his census (1974, Appendix 1) which represents less than $57 per head. There is no count of the number of nuclear families comprising economic units (including aged grandparents and single men not yet independent) but even if the number of families were as low as 100, the income per family on these figures would still be only $86.

Both the 1973 and 1974 administration patrols had noted the discrepancy between the low price paid for copra at the beach and the high price in Madang. The 1973 figure was said to be little more than half the Madang price and the patrol officer

believed that the islanders would benefit greatly from forming a co-operative and purchasing their own boat (Creagh 1973: 22). His successor shared this view, saying that the 1974 Madang price was more than twice the figure paid on Long Island. The islanders, he said, were talking of buying a boat by raising $5000 themselves and negotiating a matching grant from the P.N.G. Development Bank. However, the people seemed to aim at a monthly income of about $10 per 'producer', and thereafter were disinclined to produce more. Hence, as the price rose, production fell (Spencer 1974: 20). The term 'producer' is assumed to equate with 'family', but the figure of some $120 per year seems high, even allowing for cash sources other than copra (see below).

In 1976 Moeder purchased a smaller vessel, the pinnace 'Tagere', to pick up copra around Long Island for storage at Biliau from where it was to be collected monthly by the 'Spray' but in the same year the islanders had acquired the MV 'Arop' and began shipping their own copra to Madang. By 1978, Moeder was no longer trading on Long Island.

By that year, too, there were five hot-air dryers on the island, two each in Matapun and Bok and one in Malala. According to the government officer who prepared the 1973 survey, Long Island had another 5000 acres of land suitable for coconut palms, an area capable of increasing production many hundreds of times (Creagh 1973: 25). So far there is no evidence that the people of Long Island see the returns of labour as sufficiently high to justify any significant expansion of the area under palms.

OTHER SOURCES OF CASH INCOME

No production or sales figures are available for the minor cash crops of tobacco and betel nut, each a traditional agricultural crop now being sold for cash. Tobacco, formerly exchanged for goods in traditional trade, is now sold for cash to buyers from villages elsewhere. Betel nut, formerly grown for home consumption, is now sometimes taken to Madang for sale in the town market, and betel nut, pigs and phalanger are occasionally sent in anticipation of cash return to trade friends in Madang (Creagh 1973: 23). Pigs are also occasionally sold to visiting ships (Somers 1969: 2).

Since early colonial times the villagers of the mainland coast have supplied sea shells used for mother-of-pearl to the world's costume jewellery industry, and both bivalves and gastropods have been collected. Long Island has taken part in this trade at least since the early 1930's and probably earlier, supplying trochus (*Trochus niloticus*) and green snail *(Turbo marmoratus)*. Whether their reefs previously had the more valuable pearl oyster *(Pinctada maxima)* is not known, but the population of this species is known to have decreased throughout the district during the years between the wars. Since then, the rise of the plastics industry has greatly reduced the market.

Moeder purchased shells on the island during the 1930's and took up the trade again after World War II, continuing to encourage the collection of trochus and green snail at least until 1974. In 1974 the price being paid was 3t per pound. We have observed islanders collecting these shells around Crown Island and seen the piles of dried shells ready for collection by the 'Spray' at Moder's Biliau base. When the trade was still fairly profitable, as it was in the 1950's, Moeder would pick up a group of young island men as swimmers and circle both Long and Crown Islands for two to three weeks collecting from the reefs while the older people dried copra for him to buy when he returned the men to their home. Some shell was still being collected at Long Island for sale in Madang in 1978.

While turtles have been utilized as a resource by Long Islanders ever since the

island was resettled and occasionally been taken by visitors, either by agreement or by poaching, the rate of predation has increased markedly during the past ten years. In the early 1970's Madang poachers were taking turtles for the Madang market in an organized way, shooting sometimes up to 30 in a single night for sale at $20 each (G. E. Bailey, pers. comm.). The problem continued in 1976, the main culprits being mission workboats and other boats moving between Madang, Umboi and Lae (R. Wilson, pers. comm.). Angus (F:Botsai) told Ball that twenty years ago turtles came ashore to lay at Matapun in reasonable numbers but that by the mid 1970's it was a rare event.

The increased rate of exploitation of turtle eggs was discussed above in the section dealing with aquatic species of wild animals. The practice of selling turtle meat as well as live turtles for cash is new and growing, and it is a development which may eventually threaten the place of turtles and turtle eggs in the subsistence economy.

The agricultural officer who carried out the drought survey in 1972 thought that fish, if smoked for sale in Madang, as well as a commercial turtle trade could become a useful means of increasing cash income and that the Administration should help by finding new markets (Owet 1972: 3, 4). The patrol officer who conducted the area study of 1973 also thought that dried and smoked fish for the Madang market might repay investigation as a development option (Creagh 1973: 26).

There has been little commercial fishing around Long Island and none that has benefited the islanders. In 1976 a Taiwanese ship was observed to be long-line fishing between Long and Crown Islands for a week and apparently did some bait fishing off Crown Island (F. Moeder, pers. comm.). There has been some talk of developing a fresh fish supply to Madang (Malcolmson 1975) shipping the fish on ice, but nothing has come of it.

Income from copra is certainly significantly supplemented by cash from these other sources and the 1973 Area Study estimated the average annual total income per adult male as at least $84. At that time, savings bank deposits totalling $1842.50 were held by 28 islanders (Creagh 1973: 23) and in the following year the figures were given as 30 savings bank accounts totalling more than $2,000 (Spencer 1974: 22, 23). The same study estimated total per capita adult male income as $120 a year and compared with $80 from copra, both figures which we believe to be over-estimates, possibly by as much as a quarter.

POLITICAL CHANGE

Because of its isolation, Long Island remained outside any area of organized local government until 1973. The people became actively involved in the politics of the wider world for the first time when they voted in the House of Assembly elections in 1964, and they voted again in 1968. Both polls were preceded by special political education patrols in the Saidor Sub-district, but in 1969 the Long Islanders were said to have only a limited understanding of the purpose of voting. They asked no questions about the House of Assembly that they had twice helped to elect. In regard to local government, they were said to be quite indifferent (Bailey 1969: 1).

Although two of the candidates for the Assembly had visited Long Island, the purpose of the House of Assembly was not really understood. Every patrol carried out political education but this was thought to be no substitute for practical experience. Tax payments were seen by the patrol officers as a way of increasing the awareness of the cost of administrative and economic services, rather than as a connection with political representation; none had been paid since 1965 and there appeared to be some doubt as to whether they should have been paid. Nevertheless, it was thought that (Bailey 1969: 4, 5):

> The people would easily be able to pay four dollars a head tax per year and this would be well justified considering the services provided by the Administration . . . it is worth mentioning here that the people of Matafuna (Matapun) approached me and asked for the Administration to provide them with a new water pump . . . to replace the old pump which was Administration donated and had fallen into disrepair. I informed them that they should collect thirty dollars for the pump and the Administration would arrange for its installation. Since then nothing has been heard. In my opinion it would be beneficial to the people if they were made to pay even a token amount of money towards the services they receive . . .
>
> To them the Administration *is* the central government and they do not appreciate the niceties the House of Assembly plays in the government of the Territory. The people of Long Island overall are contented with their lot and do not appear to wish sudden changes. In fact such issues as self-government and independence are out of their sphere of interests.

Another patrol officer giving political education talks on the island late in 1969 felt that such 'political backwardness' could be overcome only by inducing the people to become more dependent on the cash economy (Somers 1969: 1).

However, a year later the ADC reported that the islanders were interested in wider political events and had expressed a desire to form a local government council on several occasions. He saw the heightened interest as resulting from increased political and economic attention from patrols during the preceding 18 months (Bailey 1970: 1, 2).

Early in 1973 the new ADC noted that the younger men were most keen to have their people join the Rai Coast Council and were impatient with the complacency of the older leaders. Only a minority appeared to have any objection to joining the local government council, the objection being connected with their cargo cult beliefs. A special political education patrol was planned for later in the year specifically to talk to selected leaders. Some of the opposition from older people was based on opposition to council taxes, but they seemed reassured when told that these would not be high. The only outright opposition was from a few cargo cultists (Creagh 1973: 8, 20, 27). The special political education patrol took place in June and was followed up twice later in 1973, and thought to be effective (Spencer 1974: 18, 25).

Also in 1973, a meeting of the Rai Coast Council resolved to incorporate Long Island into the council area, dividing the island into three wards each with its own councillor, and this was put into effect before the year was out. The three wards were identified with Malala, Matapun, and Kaut and Bok together. During the election a high level of understanding of the purpose and processes was shown, and it was readily agreed that the council tax should be two dollars per adult male. There was some apprehension that the mainland majority on the council would impose its will on Long Island but it was thought by the patrol officer that the investment of council funds in Long Island development projects would soon convert the doubters. Initially, the council was to provide wells and pumps for the four main villages using central government rural improvement funds and spend $1,000 improving the airstrip. It also promised further spending on the school and on an aid post (Spencer 1974: 18, 25-7). (The pumps were duly installed but by October 1978 all were inoperative due to lack of maintenance.) Council-initiated activities have steadily increased the degree of integration of Long Island into the Rai Coast Council hegemony. The council-assisted purchase of the MV Arop has already been noted and the Council has made rules limiting bride-price payments for Long Island (K200 for Bok, K100 for Matapun) and encouraged the construction of a walking track around the island. By 1978 Long Islanders were suggesting that the island should have its own representative in the new Provincial Assembly (Apa mo78).

In the six years since joining the Council in 1973 the Long Islanders have received more cash development grants per capita from the Council than any other Rai Coast electors (DO W. R. Wilkinson, letter 13.6.79). Table 13 shows how the money was spent.

TABLE 13. Rai Coast Council expenditures on Long Island since Long Island joined the Council in 1973.

Year	Project	Amount (Kina)
1973-4	Matapun water pump	318
	Bok water pump	300
	Malala water pump	300
	Kaut water pump	318
	Matapun airstrip	823
1974-5	Matapun classroom	2,495
	Bok aidpost	943
	Matapun airstrip	503
1975-6	Work boat — MV 'Arop'	10,562
1976-7	Work boat — MV 'Arop'	1,596
1977-8	Work boat — MV 'Arop'	1,790
1979	Tools — Long Island road	1,200
		21,148
	People's Contribution — work boat — MV 'Arop'	–1,061
		20,087

DEVELOPMENT AND CONSERVATION

Patrol reports and correspondence throughout the 1960's and 1970's continually and often despairingly stressed the need for economic development. Typical of many such exchanges were those resulting from a routine patrol in mid-1969. The patrol officer reported 'The economic development of Long Island is virtually nil . . . there are no vehicular roads . . . no airstrips'. He went on:

> It is impractical at this stage to envisage the implementation of any other type of economic development bar copra production as this is all that the island is suitable for. A small fishing industry would be feasible as fish are in sufficient numbers to sell to the Madang Freezer but the people do not have the necessary capital.
>
> People of this island if they are going to achieve anything economically will need close and continued attention by the Administration if they are to rouse themselves from their lethargy. To educate them to what for them is a new way of life will take time and patience (Bailey 1969: 1, 3).

In reply, the DC, Madang, proposed 'that one of your officers be made responsible for implementing a Long Island Development Scheme' (letter, 16.9.69) and he reported to secretary of the Department of the Administrator (letter, 16.9.69):

> The ADC . . . does not paint a very attractive or hopeful picture of the Long Island scene. Unfortunately the picture painted is only too true to life. The small population, total lack of incentive, remoteness of the island and rough seas for six months of the year, all combine to the end result of a depressed economy and a disinterested people.

The departmental secretary agreed that these factors produced 'quite a difficult problem' (letter to DC, 6.10.69), but the ADC came forward with a plan for 'Long Island Economic Development' based on copra (letter 20.10.69) and was instructed to 'implement as soon as possible' (DC to ADC, 30.10.69). As earlier sections of this study

have shown the results have been limited.

Another approach to Long Island's future, seen by some as complementary and by others as alternative, began to emerge at about this time.

The need to conserve the biological resources upon which the subsistence economy depends, especially the wild protein sources, had been noted by some outsiders such as the trader Moeder. The most conspicuous threat was to the supply of turtle eggs (discussed above) and to the eggs of the brush turkey — the megapode. Poin Kiau, for example, had been named for the abundance of megapode eggs to be found there. The promontory had once been 'black with fowls laying eggs' and ships sailing between Madang and New Britain would stop to fill 4-gallon kerosene tins with eggs (F. Moeder, pers. comm.).

The combined effects of 'development' and human population growth have put an end to this egg-ground. In 1974 a marine navigation light was mounted on steel piles driven deep into the ground on the extremity of the point and the sand-spit has since largely disappeared. At the same time, the growth of Poin Kiau settlement from an isolated garden house to hamlet has made the demand for eggs a constant one and has also led to further habitat destruction. School children moving between Malala and Matapun have added to the depredation and now the growth of a new school community at Poin Kiau has further increased the harvesting of both wildfowl and turtle eggs by permanent settlers.

The people have adapted in part by agreeing to cease egg collection from time to time to allow some population recovery to take place, and there are a number of other megapode laying areas under less constant pressure.

The turtle population is under a greater threat. It has been most seriously affected by the increase in the human population, by permanent settlement on the north coast, by the increased traffic along that coast generated by the growth in importance of Matapun with its government school and by increasing incentives to convert traditional subsistence resources into cash.

In Moeder's opinion, Long Island lacks a good turtle nursery ground, having no fringing reefs, so that most of the young turtles are taken by sharks. By contrast, much of Crown Island has an outer reef enclosing a lagoon some ten metres deep in which small to medium sized turtles abound (F. Moeder, pers. comm.).

The great increase in recent times of the rate of exploitation of turtle eggs and turtles by the people of Long Island and by visitors has been discussed in an earlier section.

A more general approach to the conservation of Long Island's resources as a matter of wider regional and national interest was developing at the same time as the renewed emphasis on economic growth. Some reference to the potential role of Long Island in wildlife conservation must have been made in Saidor-Madang correspondence in late 1969, but the earliest clear statement that we have found was made by the ADC, G. E. Bailey, who concluded his report of a 1970 patrol by saying 'Long Island would be an excellent site for a wildlife sanctuary'. He noted that there were at that time no shot-guns locally owned on Long Island (Bailey 1970: 2). As previously mentioned, one or two shot-guns were said to have reached the island in 1973 and 1974 but now the Long Islanders have supposedly agreed to limit their use (PNG Post Courier, Oct. 28, 1977).

Despite increasing zoological knowledge and the dawning awareness in some quarters of the need for conservation measures for the turtle population, outside pressure to 'develop' Long Island (in keeping with official policy) was such that in 1972

the Rural Development Officer suggested that cash income could be increased by selling more turtles (in addition to copra and shells) and that the administration could help by finding markets (Owet 1972: 4).

At the same time, official interest in the establishment of national parks was growing, and in November 1972 staff from the Wildlife Section, DASF, accompanied by Hughes, then with the New Guinea Research Unit of the ANU, and John Winslow, a geographer of the University of Papua New Guinea, visited Long and Crown Islands to evaluate their potential as conservation areas and to enquire about the inhabitants' attitudes to this approach. (Ball and Glucksman were concurrently working in the caldera). The concept of a conservation area was quite foreign to the people but when the depletion of turtles was discussed all were keen to prevent their exploitation by *outsiders*. A few informants thought that some restriction was also needed on their use by local residents.

The expedition made three recommendations in 1973 (Lindgren 1975: Appendix 1, 4):

> 1. That Long and Crown Islands and surrounding waters to a depth of 50 m be declared a Conservation Area in particular for the scenic attributes, wildlife and wilderness areas.
>
> 1a It is preferable that the area be declared a National Park to allow controlled development when required.
>
> 1b Further investigations should be carried out by the National Parks Board to determine attitudes of the permanent inhabitants to this suggestion.
>
> 2. That, as shotguns are superfluous to the peoples' current needs, they be banned from both islands.
>
> 3. That the Wildlife Section DASF conduct further research into the turtle breeding grounds and develop a management plan to ensure their continuity.

In the following June, Hughes arranged to take the archaeologists Egloff and Specht (1982) to the island's prehistoric sites and the National Parks Board was invited to send a representative to make a first-hand appraisal. For the Parks Board, R. Miniotas noted the value as a national park, but he stressed the potential for tourist development along the lines of national parks in developed countries. He recommended (Miniotas 1973: 4, 6-8):

> (1)the whole of Long Island, its natural resources and the people, be declared as a 'protective area' where nature conservation can be practised and economic development of resource extraction type be prohibited.
>
> (2)Because of the island's varied resources and the need to maintain the people's rights and wants the following zoning is proposed:
>
> (i) A totally protected area where the natural and scientifically important aspects and species can be preserved, as for example turtle egg laying beaches, wildfowl breeding grounds, Motmot crater.
>
> (ii) Wilderness areas where passive form [sic] of outdoor recreation is promoted. All man made structures and facilities, except perhaps primitive walking tracks, should be totally excluded.
>
> (iii) Outdoor recreation areas where active pursuits are encouraged and where accommodation and other similar facilities are available.
>
> (iv) Communal areas where visitors can mingle with the local people and freely inspect villages, artifacts and cultural dancing.
>
> (v) Large areas reserved strictly for the use of the local inhabitants where the normal village, gardening and hunting activities can be carried out free of outside interference.

These various proposals appear to have received little attention at the sub-district level, and in 1975 Lindgren of the Wildlife Section, DASF, produced a land-use plan (Lindgren, 1975, 3-13), in which he suggested that, in general, Long and Crown Islands should be maintained as a predominantly wilderness-oriented conservation area, the antithesis of promoted economic development. He proposed the declaration of four zones — residential, game management, wilderness and restricted.

The residential area would contain all villages and most subsistence gardens and would be defined by the coast and the 65 m contour. (Most gardens already lay in that zone). Any tourist development would also have to take place within that zone, together with any associated offices for administration and wildlife management. Should tourist development be decided upon, it should be located on the Monono River on the central east coast and be serviced by a new airstrip on Balim Point. Any such venture should maintain a low profile, be small in scale, specialize in tourists seeking wilderness values and offer accommodation in buildings built of native materials harmonizing with the landscape.

The game management area would extend from sea level to the 165 m contour and act as a buffer zone. While traditional uses could continue at the present level, no increased use would be permitted. Species principally affected were identified as turtles, megapodes, phalangers and feral pigs. Firearms should be prohibited from the island, and if the program was to succeed it was essential that the need for it be fully accepted by the local people. To this end, a public education program would be needed, together with research into the population biology of the phalanger and the effect on it of traditional hunting.

All turtle species were declining in number, said Lindgren, and the leathery turtle was especially threatened. Further research was needed in addition to a public education program in turtle biology and ecology, sections of beach should be fenced off from pigs and people to form protected hatcheries. Crown Island should be a sanctuary, with no harvesting permitted.

Statistics should be collected on megapodes and their breeding, and on the feral pig population.

Land above 165 m MSL, at present rarely visited by anyone, should be declared a wilderness area and managed by the National Parks Board. It should be preserved in as pristine a state as possible, serving the dual purposes of low-impact recreation and protected areas for replenishing animal populations hunted in the game-management area. Access to the crater should be restricted to a small number of walking tracks. Crown Island should be a wilderness area entirely.

Sites of spiritual, archaeological or scientific significance, such as Motkono (the small stack-island off the south-east coast), the prehistoric sites and any others later identified should be declared restricted areas, access being granted only to the people of Long Island and to permit holders.

If the overall concept was acceptable to the people, said Lindgren, an Island Management Committee should be formed representing all settlements. Local participation in planning and management was essential and planning details and management techniques should be worked out jointly with the National Parks Board and Wildlife Section DASF.

Referring to the important role of phalanger in the diet of the people of Long Island, Lindgren observed that even without the introduction of firearms, this species would decline in numbers if the human population was allowed to grow to a level where predation became excessive (1975: 7). His prediction applies equally to all the

other species that now supply protein to the diets of the villagers of Long Island, and is a reminder that elsewhere in Papua New Guinea there are large areas where, even without modern economic development, human numbers have grown to a level where game animals formerly significant both in diet and in cultural life, have virtually disappeared. Recent census data examined by Ball show that there are now many large families in Malala, Kaut and Bok, some with eight or nine surviving children and many with six or seven; human population numbers are now growing rapidly.

Under the provisions of the appropriate legislation (borrowed from similar arrangements in developed countries) National Parks require the transfer of land ownership to the state; this the people refused. As an alternative, in 1976 it was proposed to make Long and Crown Islands a wildlife management area in which the residents could fish and hunt by traditional methods quite freely within traditional limits but where outsiders would need to obtain permission (R. Wilson, pers. comm.). The arrangement finally enacted was a two-part division patterned in part on Lindgren's recommendations, with the outer portion of Long Island a Wildlife Management Area requiring outsiders to have permits to fish or hunt, and the inner portion of Long Island and the whole of Crown Island as Wildlife Sanctuaries requiring outsiders to have permits to enter for any reason (letter, 27.7.78, Administrative Secretary Division of Provincial Affairs, Madang; letter, 14.8.78, Wildlife Division, Department of Lands and Environment, Port Moresby). The suggestion for tourist development has not been taken up.

There is now a management committee on Long Island which includes the three councillors and representatives from each village but there are evident problems in enforcing the provisions of the legislation. R. Wilson of the Wildlife Division, Madang, considers the turtle population to be seriously threatened still, and cited examples of their exploitation for cash by Long Islanders and visitors. While the residents profess concern, he said, they send turtles for cash sale to Madang market. Despite an education program, wildlife officers of the central administration are pessimistic about the future of breeding populations of turtles laying on the beaches of Long Island.

Because of its isolation, Long Island is just beginning to experience the development process that much of Papua New Guinea has been undergoing for many years. To the outside observer, the present trend is clear. The rate of population growth that modern health measures allow, combined with the desire for cash and the goods that money can buy will transform the island's ecology and economy. Missions, commercial interests, development agencies and official policies all encourage 'consumerism'. The community will develop from a self-sufficient one unusually rich in subsistence resources and adequately supplied with the resources for traditional trade, into a community increasingly dependent upon Madang market for sales and for the supplies needed to replace resources made inadequate by their exploitation for cash and by increasing human numbers. No policy exists on the latter problem; it is not yet seen as a problem at home or abroad.

As increased personal wealth and ownership of manufactures becomes the goal of the majority, a tourist industry may become attractive, especially if locally owned and operated. If carefully regulated, it would bring money and provide some employment and it would make less impact on the island's animal populations (either by direct predation or by habitat destruction) than would other forms of commercial exploitation. If appropriately planned and managed, its success would require the preservation of most of the island's wilderness values.

Many of the people of Long Island are now beginning to abandon the leisure characteristic of their traditional culture for the treadmill of the monetized economy, in general without realizing the process in which they are involved. When Hughes

visited Lake Wisdom in 1972, only one of his four Malala companions had ever before visited the crater rim and that only once, and he had never descended to the water's edge. The abundance of game made even travel for hunting strictly parochial; local resources were sufficient for each village and horizons were close. Those familiar with wider horizons and who have studied the development process have a responsibility to provide the people of Long Island with an accurate statement of the costs as well as the benefits of the course upon which they are embarking, together with full information about alternatives that may be available.

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Z'graggen, J. A., 1975. The languages of the Madang District, Papua New Guinea. *Pacific Linguistics Series B,* No. 41. Department of Linguistics. Research School of Pacific Studies, Australian National University, Canberra.

——— 1976. Austronesian languages: Madang Province. In S.A. Wurm (ed.), *New Guinea Area Languages and Language Study, Vol. 2. Austronesian Languages:* 285-298. Department of Linguistics, Research School of Pacific Studies, Australian National University, Canberra.

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ANNOTATED BIBLIOGRAPHY OF REFERENCES RELATING TO LONG ISLAND, PAPUA NEW GUINEA

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This bibliography is an attempt to include all works published before 1900 which mention Long Island, as well as later studies, up to 1979, which make a significant contribution to our knowledge. Unpublished documents have proved important sources of information, and I have included those which I have seen. No doubt there are others which have been omitted. I have cited relevant newspaper articles that I knew of but there has been no systematic examination of newspapers. Citations are as given in library cataloging systems. For each entry a summary is given of information relating to Long Island. German language entries have been translated with the help of V.B. Meyer-Rochow and G. Stange.

Allied Geographical Section, 1943a. *Southwest Pacific Area. Terrain Study No. 59. Area Study of Madang,* Volume 1.

Overall geographical summary of conditions on the island covering: (a) offshore conditions; (b) anchorages and coastline; (c) villages; (d) tracks and movement; (e) lakes and swamps; (f) vegetation; (g) resources; (h) population; (i) administration; (j) meteorological information; (k) other general matters. The information, compiled from interviews and aerial photographs, is fragmentary and occasionally in error.

Allied Geographical Section, 1943b. *Southwest Pacific Area. Terrain Handbook No. 14. New Guinea: Saidor.*

Rainfall and weather data for Rai Coast and Cape Rigny. Superseded by McAlpine *et al.*, 1975.

Anderson, M. A., 1978/79. Comments on the presence of a crocodile or crocodiles in Lake Wisdom on Long Island, north of New Guinea. *Science in New Guinea* 6(1): 6-8.

Infers that crocodiles can climb up and down steep slopes and that the species living in Lake Wisdom is '*Crocodilus* [*Crocodylus*] *porosus*'. States (incorrectly) that, 'the coast of Long Island lacks suitable habitats for crocodiles'.

Australia, Parliament, 1923. *Report to the League of Nations on the Administration of the Territory of New Guinea from 1st July, 1921, to 30th June, 1922.* Government Printer for the state of Victoria, Melbourne.

#36 Long Island, in latitude 5°20'S, longitude 147°10'E, about 35 miles from the coast, is an island of low hills, with two cone-shaped craters, one of which is 2000 feet high. Its area is about 170 square miles. It has no harbours or anchorages, and is reported to be uninhabited. Crown Island is about 10 miles to the north-west of Long Island and is apparently not inhabited.

Australia, Prime Minister's Department, 1937. *Official Handbook of the Territory of New Guinea Administered by the Commonwealth of Australia.* Commonwealth Government Printer, Canberra: 96.

Long Island, in latitude 5 deg. 20 min. S., longitude 147 deg., 10 min. E., about 30 miles from the coast, is an island of low hills with two cone-shaped craters, one of which, Reumur Peak, is 4278 feet high, and the other, Cerisy Peak, 3,727 feet. Its area is about 160 square miles. It has no harbours or anchorages, and is inhabited*.

*A party landed on Long Island in February, 1928, and after climbing the steep sides of a mountain to a height of some 1,500 feet, looked down on the waters of a lake, about 4 miles by 5, about 1,000 feet below them. The shore natives, numbering approximately 300, are immigrants from Siassi Islands: they declare that the heights are inhabited by natives whom they have never seen, but whom they blame for the disappearance of their women from time to time. The name Lake Wisdom was given to the lake. It is interesting to note that in 1921 the island was reported as uninhabited.

Ball, E., 1977. Life among the ashes. *Australian Natural History* 19(1): 12-17.

Popular account of the biological colonization of Motmot Island in Lake Wisdom, 1969-74.

Ball, E. E., 1982. Long Island, Papua New Guinea — European exploration and recorded contacts to the end of the Pacific War. *Rec. Aust. Mus.* 34(9): 447-461.

Summarizes European contact with and knowledge of Long Island up to the end of World War II. Includes extensive quotes from original sources.

Ball, E. E. and J. Glucksman, 1975. Biological colonization of Motmot, a recently-created tropical island. *Proc. R. Soc. Lond. B.* 190: 421-442.

Summarizes the geological history of Motmot and its biological colonization 1969-72.

Ball, E. E. and J. Glucksman, 1978. Limnological studies of Lake Wisdom, a large New Guinea caldera lake with a simple fauna. *Freshwater Biology* 8: 455-468.

Summarizes physical conditions and biota of Lake Wisdom from observations made 1969-1976. An approximate bathymetric map is presented along with data on temperature, water chemistry, 0_2 saturation, and light penetration in relation to depth. The relatively simple biota of the lake is described and it is suggested that this simplicity is due to creation of the lake within the past 300 years combined with the relatively long distance from sources of colonists.

Ball, E. E. and J. Glucksman, in press. Biological colonization of a newly-created tropical volcanic island & limnological studies on New Guinea lakes, 1972-1978. *National Geographic Society Research Reports, 1972.* National Geographic Society, Washington, D.C.

Brief summary of the colonization of Motmot 1969-1978 and comparison of the physical properties and biotas of Lake Wisdom and Lake Dakataua (West New Britain).

Ball, E. E. and J. Glucksman, 1980. A limnological survey of Lake Dakataua, a large caldera lake on West New Britain, Papua New Guinea, with comparisons to Lake Wisdom, a younger nearby caldera lake. *Freshwater Biology* 10:73–84.

Compares the biota and physical characteristics of two New Guinea caldera lakes; Lake Dakataua and Lake Wisdom. Hypothesizes that the simpler biota of Lake Wisdom is due to the shorter time since creation of the lake and the greater distance from sources of colonists.

Ball, E. E. and I. M. Hughes, 1982. Long Island, Papua New Guinea — People, Resources and Culture. *Rec. Aust. Mus.* 34(10): 463-525.

Discusses most aspects of life on Long Island with emphasis on the human history

and the relation between the people and their environment.

Ball, E. E. and R. W. Johnson, 1976. Volcanic history of Long Island, Papua New Guinea. In R. W. Johnson (ed.), *Volcanism in Australasia:* 133-147. Elsevier, Amsterdam.

Summarizes geological history of the island from geological observations, oral traditions and historical accounts.

Bamler, G., 1911. Tami. In R. Neuhauss (ed.), *Deutsch Neu-Guinea,* Vol. III: 489-566. Dietrich Reimer A. G., Berlin.

A mythical figure Panku venerated on both Long and Umboi Islands was considered by the Tami Islanders to be responsible for a catastrophic landslide from Cerisy Peak on Long Island. (This landslide is said to have been discussed by von Schleinitz in *Nachrichten aus Kaiser Wilhelmsland,* 1887, but I have been unable to locate this reference). A further mention of Long Island is (p.524-525):

> On the other hand there exists a tale that in earlier days Long Island had a connection with New Guinea and that the land went down in a stormy night. Of course the natives tell this story as a tale that an old woman had cursed the land; but which natural event would not be explained by the native as supernatural interactions by evil spirits. In any case this sinking took place centuries ago.

In the legend of Panku langa and Anuto, it is stated (p. 548) that Panku was not seen again, 'until he beat the Kamalandjaleute (Long Island)'. Concerning this legend Bamler states (p. 548):

> Probably this tale is a historical reminiscence. Panku was a whaler, as they frequently fished around Rook one hundred years ago. Kapi Molo also seems to be the name of a white man: Kapi = captain. The statement, 'he beat the Kamalandja people' refers to a catastrophe on Cerisy Peak on Long Island, (landslide, mountain collapse) noted by Freiherrn von Schleinitz in the journal Nachrichten aus Kaiser Wilhelmsland, 1887; 'The disaster cannot be very old, the traces are still too fresh'. Disasters of this kind were attributed to white men the same way as the disaster of March, 1888, was blamed on the white men Hunstein and von Below.

Bamler, G., 1912. Das Erdbeben vom 14 auf den 15 September 1906. *Naturhistorische Gesellschaft Nuremberg Abhandlungen* 19:17-18

> . . . Of large catastrophes there is only one memorized (remembered), the collapse of the volcano on Long Island. This happened during the lifetimes of the grandfathers of the oldest men now living, which is about 100 years ago. Some other reports are entirely legendary. For example that disaster on Long Island has been exploited into legends . . .
> . . . More interesting with regard to the last earthquake is the legend that Long Island was connected to mainland New Guinea in the past. Unfortunately, I have forgotten the exact contents of the tale. I only remember it was something about a grandmother and grandchild. The grandmother was angered at something and in her anger she enchanted the country which was destroyed by a big tidal wave, that is to say the land sank.

Bassot, J. M. and E. E. Ball, 1972. Biological colonization of recently created islands in Lake Wisdom, Long Island, Papua New Guinea with observations on the fauna of the lake. *Papua New Guinea Sci. Soc. Proc. 1971* 23: 26-35.

Presents initial observations of Motmot and of the fauna and flora of Lake Wisdom based on a visit in 1969. Superseded by Ball and Glucksman 1975, 1978.

Bennigsen, R. von, 1900. Über eine Expedition im Hinterlande von Friederich-Wilhelmshafen und Stephansort. *Deutsches Kolonialblatt* 11: 324-326.

Reports visit of 1900; 'We approached Long Island for a short time, without anchoring, because Mr Boag wished to confer with the natives about hiring them in the future. A canoe came alongside with two men in war regalia and the people were presented with many gifts on the promise that we would soon come again. The apparently fruitful and well-wooded island is only thinly populated by a tribe whose appearance indicates their relationship with the Papuans.'

Bennigsen, R. von, 1901. Reise des Gouverneures nach dem Süden von Deutsch-Neu-Guinea. *Deutsches Kolonialblatt* 12: 282-283.

Von Bennigsen sailed between Long Island and Lottin Island in 1900 but did not land.

Best, J. G., 1956a. Investigations of recent volcanic activity in the Territory of New Guinea. *Bur. Miner. Resour. Aust. Rec. 1956/12.* Unpublished.

Contains short sections on the physiography, structure and past volcanic activity of Long Island, and a good description of the 1953 eruption of Motmot.

Best, J. G., 1956b. Investigations of recent volcanic activity in the Territory of New Guinea. *Proc. 8th Pacific Science Congress, Manila, 1953.* Vol II Geology, Geophysics and Meteorology: 180-204.

Identical to Best, 1956a, but contains photographs.

Blong, R. J., 1975. The Krakatoa myth and the New Guinea highlands. *J. Polynes. Soc.* 84: 213-217.

Discusses the relation between 'times of darkness' as described by highlands people and known volcanic eruptions. Discards the idea that the eruption of Krakatoa may have been a significant source of ash in the highlands, and suggests Long Island, among others, as a possible source for the ash which caused the 'times of darkness'

Blong, R. J., 1979. Huli legends and volcanic eruptions, Papua New Guinea. *Search* 10: 93-94.

States that the most recent 'time of darkness' recorded in Huli legends was associated with deposition of the Tibito Tephra which was erupted 'circa 1700 AD' from Long Island. A map is presented showing the approximate location of the 1.5 cm compacted thickness isopach of the Tibito Tephra.

Blong, R. J., C. F. Pain and C. O. McKee, 1982. Geomorphology and tephrostratigraphy of Long Island, Papua New Guinea. *Rec. Aust. Mus.* 34(7): 419-426.

Covers basically the same material on the geomorphology and tephrostratigraphy of Long Island as Pain, Blong and McKee (in press), but in somewhat less detail.

Bodrogi, T., 1961. *Art in north-east New Guinea.* Translated by E. Racz. Hungarian Academy of Sciences, Budapest.

General description of ethnography and art styles of the islands of Vitiaz Strait and the coast of the Huon Peninsula. Long Island is incorrectly described as being uninhabited.

Bodrogi, T., 1969. Data regarding the ethnography of Umboi and the Siassi Islands. *Acta Ethnographica* 18 (1-3): 187-228.

Discusses Long Island in relation to 'Kultur C' of Schmitz and the Kilibob-Manup

legend. Argues that the Austronesian speakers now on Long Island and the adjacent islands came from the direction of Karkar Island, and that Long, Siassi and Umboi eventually became 'centres of gravity' of that culture.

Braun, F. and C. V. Sheathsley, 1937. *On both sides of the Equator.* Lutheran Book Concern, Columbus, Ohio: 122.

The plan was adopted to take the territory along the Rai Coast and to the Finisterre mountains, with the new station Ulap and the older station Sio adjoining, These stations with Siassi, Rook, Lotin and Long Island formed the 'Finisterre District' or American sphere of interest.

Bridge, Capt. C. A. G. to Rear-Admiral George Tryon, C. B., 1885. *Supplement to the New South Wales Government Gazette No. 123.* Monday, 23rd March, 1885: 2003-5.

Brief description of visit of H.M.S. 'Dart' to Long Island on January 16th, 1885, for the purpose of declaring it a British Protectorate.

14. Dull weather and heavy rains, during which dangers could not be discerned till close to, prevailed on January 16th, on which day the 'Dart' reached Long Island. After examining the eastern and south-western shores without being able to discover any natives, I directed Lieutenant and Commander Moore to return to the southern point at which I landed, and having on a bluff some 40 feet high above the sea set up a flag-staff, hoisted the British flag and read the Proclamation. A copy of the Proclamation was nailed to the flag-staff.

Carey, S. W. 1938. The morphology of New Guinea. *The Australian Geographer* 3 (5): 3-31.

The next volcanic line passes through Long and Crown Islands and is continued in a north-westerly direction as a submarine ridge. Crown Island appears to be a truncated cone nearly 2,000 feet high and about 10 miles in circumference. Long Island is a large island with a rim of steep mountains up to 4278 feet in height, surrounding an elevated caldera lake about 20 square miles in extent. Mr Nurton, Patrol Officer, who visited the island in 1932, estimated from native lore that the catastrophic explosion which formed the caldera occurred about 300 years ago. The rain of ash and debris destroyed all life on the island as well as on Crown Island 12 to 15 miles to the north-west, and deaths occurred in the Siassi Group over 60 miles away. The present inhabitants are descendants of Siassi Islanders who colonized the island three generations ago.

Chalmers, J., n.d. (1887). *Pioneering in New Guinea.* Religious Tract Society, London.

Account of the declaration of Long Island as part of the British Protectorate in 1885:

By 7.30 we were in the open, in a deluge of rain, steaming to Long Island. This is another of those at one time active, living volcanoes, now dead, living only in newer life and truer beauty. From the base of the highest peak — 1,500 feet — a long low ridge runs, which, when some distance off, gives the appearance of a very long island. We sailed well round it, but could see no appearance of living beings, neither house nor plantation. We could not land on the north-west side, so decided to hoist the flag on the high south side on a prominent place. We landed, and ascended an embankment of volcanic earth, about forty feet above sea-level, and there dug a small hole, close by a stump. The pole was raised and fastened to the stump, and again Captain Bridge performed the ceremony. The opportunity was favourable to address the officers and men, and in kind and well-chosen words he told them how pleased he was with the manner in which the work had been done, and what satisfaction he would have in reporting to the proper quarter respecting Captain Moore, his officers and men.

Chinnery, E. W. P., n.d. (1927?). Certain natives in south New Britain and Dampier Straits. *Territory of New Guinea. Anthropological Report No. 3.* Government Printer, Melbourne: 33.

Mr. Bamler has supplied a vocabulary (Appendix B) of the languages spoken at Barim. According to his notes it extends to Tolokiwa and Long Island, both of which lie west of Umboi. He goes on to say that only two of the Rook Island groups now speak this dialect. They are Barim and Alonai, a small island near Mandok. One man of Barim told me that a similar language is spoken at Kiari, near Segaba, on the Rai Coast of New Guinea.

Cooke, R. J. S., C. O. McKee, V. F. Dent and D. A. Wallace, 1976. A striking sequence of volcanic eruptions in the Bismarck volcanic arc, Papua New Guinea, in 1972-75. In R. W. Johnson (ed.), *Volcanism in Australasia:* 149-72. Elsevier, Amsterdam.

Describes the 1973-74 eruptions of Motmot in considerable detail.

Coultas, W. F. 1933-35. *Journal and letters of William F. Coultas*. Vol. IV. Whitney South Sea Expedition, October 1933-March 1935. Unpublished, in Dept of Ornithology, American Museum of Natural History, New York.

Invaluable extensive description of how the Long Island people lived in 1933. Contains information on all aspects of life including food, clothing, housing, social interactions, contacts with the outside world, etc. Valuable source concerning avifauna and other wildlife in 1933. Extensively quoted in Ball (1982) and Ball and Hughes (1982).

D'Addario, G. W., 1972. The 1968 eruption of Long Island. Appendix 2, pp. 110-112 in Johnson, Taylor and Davies, Geology and petrology of quaternary volcanic islands off the north coast of New Guinea. *Bur. Miner. Resour. Aust. Rec. 1972/21.* Unpublished.

Describes the 1968 eruption which created Motmot, the island in Lake Wisdom.

Dampier, W., 1729. *A Voyage to New Holland.* 1939 edition. J. A. Williamson (ed.). The Argonaut Press, London: 218-219.

Brief description of Long and Crown Islands, and their naming in 1700.

The 31st in the Forenoon we shot in between 2 Islands, lying about 4 Leagues asunder; with Intention to pass between them. The Southermost is a Long Island, with a high Hill at each End; this I named Long Island. The Northermost is a round high Island towering up with several Heads or Tops, something resembling a Crown; this I named Crown-Isle, from its Form. Both these Islands appear'd very pleasant, having Spots of green Savannahs mixt among the Wood-land: The Trees appeared very green and flourishing, and some of them looked white and full of Blossoms. We past close by Crown-Isle; saw many Coco-nut-Trees on the Bays and the Sides of the Hills; and one Boat was coming off from the Shore, but return'd again. We saw no Smoaks on either of the Islands, neither did we see any Plantations; and it is probable they are not very well peopled. We saw many Shoals near Crown-Island, and Riffs of Rocks running off from the Points, a Mile or more into the sea. My Boat was once over-board, with Design to have sent her ashore; but having little Wind, and seeing some Shoals, I hoisted her in again, and stood off out of Danger.

Deutsche Kolonialzeitung, 1897. Einiges über die Eingeborenen von Bogadjim, Astrolabebai, Kaiser Wilhelmsland. *Deutsche Kolonialzeitung* 10(38): 379-80.

Early version, collected by the missionary Hoffmann at Bogadjim Village, of the Kilibob-Mandumba (Manup) legend, including a description of the creation of Long Island for Mandumba.

Deutsche Kolonialzeitung, 1910. Südsee-Expedition der Hamburgischen Wissenschaftlichen Stiftung. *Deutsche Kolonialzeitung* 27(6): 87-88.

Says that the expedition stopped at Long Island, but no details are given.

Dexter, D. S. A., 1961. *Australia in the War of 1939-1945. Army. The New Guinea Offensives,* Australian War Memorial, Canberra. Pp. 522, 731.

Long Island was an important barge hideout for the Japanese during 1943. Describes occupation of Long Island by U.S. and Australian troops in late December 1943.

Diamond, J. M., 1974a. Recolonization of exploded volcanic islands by New Guinea birds. *Explorers Journal* 52(1): 2-11

Popular account of the author's 1972 survey of the avifauna of Long Island and the adjacent islands.

Diamond, J. M., 1974b. Colonization of exploded volcanic islands by birds: the supertramp strategy. *Science* 184: 803-6.

Description and comparison of avifaunas on islands in the Vitiaz Strait. Long Island is of special interest due to its recolonization following defaunation by an eruption during the eighteenth century. It has a paucity of montane bird species but high overall bird density especially of 'supertramps' which specialize in overseas colonization and rapid breeding.

Diamond, J. M., 1975. Assembly of species communities. In M. J. Cody and J. M. Diamond (eds.)., *Ecology and Evolution of Communities:* 342-444. Belknap, Cambridge (Mass.).

Discusses composition and size of avifauna of Long Island in relation to island size and time since defaunation.

Diamond, J. M., 1976. Preliminary results of an ornithological exploration of the islands of Vitiaz and Dampier Straits, Papua New Guinea. *Emu* 76: 1-7.

Birds of special interest on Long Island were *Falco berigora* and *Numenius madagascariensis.* The occurrence of several other species is discussed.

Diamond, J. M., 1977. Colonization of a volcano inside a volcano. *Nature* 270: 13-14.

Good brief summary of the studies of Ball and Glucksman on the colonization of Motmot (an island in Lake Wisdom) and the limnology of the lake.

Diamond, J. M., 1980. Reconstitution of bird community structure on Long Island, New Guinea, after a volcanic explosion. *National Geographic Society Research Reports 1972.* National Geographic Society, Washington, D.C.

Discusses avifaunal community structure of Long Island.

Dumont D'Urville, J. S. C., 1832. *Voyage de la corvette L'Astrolabe exécuté par ordre du Roi, pendant les années* 1826-1827-1828-1829. *Sous le commandement de M. J. Dumont D'Urville, Capitaine de Vaisseau. Histoire du Voyage.* Vol. 4. J. Tastu, Paris: 543-544.

At one o'clock we were already beneath the steep and rugged flanks of Mt. Reaumur, which also appeared to have been a volcano, and we followed, at a distance of less

than two miles, the deserted beaches of Long Island.
This island was quite incorrectly named by Dampier, probably because of the first view of the island which that navigator saw, because it has a rather round shape and its circumference is not less than forty miles. The ground in the vicinity of the shore appeared more arid than all the other islands and we saw neither coconut trees nor any trace of inhabitants.
Crown Island, which is no more than seven miles to the NW of Long Island, is a plateau four or five miles in circumference and of great height. The ground, although rugged, showed no sign of the sharp ridges which caused Dampier to give it the name Crown Island. Perhaps because the irregularities had been effaced by the growth of forest with the passage of time, perhaps because that navigator, having passed closer to the island than me, was in a better position to see these things. There was no sign of smoke nor inhabitants; the sea was so calm that it is probable we would have seen a few canoes, had the island been inhabited.

Egloff, B. J., 1975. Archaeological investigations in the coastal Madang area and on Eloaue Island of the St. Matthias Group. *Rec. Papua New Guinea Museum*, No. 5.

Presents preliminary account of archaeological sites on Long Island described more fully in Egloff and Specht (1982), and refers these to his more extensive work in the Madang area.

Egloff, B. J. and J. R. Specht, 1982. Long Island, Papua New Guinea — Aspects of the Prehistory. *Rec. Aust. Mus.* 34(8): 427-446.

Description of five Long Island archaeological sites and the artefacts found there. The oldest of these sites dates from 1040±80 years bp. The significance of finds of obsidian and potsherds is discussed, especially in relation to trade connections.

Evans, G., 1940. The characteristic vegetation of recent volcanic islands in the Pacific. *Kew Bulletin — 1939*: 43-44.

Describes the coastal vegetation on the basis of a three day visit to Long Island in 1925. Did not see any evidence that the island was inhabited. Contains several erroneous statements about the island.

Feldt, E., 1946. *The Coast Watchers.* Oxford University Press, Melbourne.

Describes the landing of coast watchers on Long Island in October 1943, several months before the arrival of Allied troops.

Findlay, A. G., 1877. *A directory for the navigation of the South Pacific Ocean with descriptions of its coasts, islands, etc. from the Strait of Magalhaens to Panama, and those of New Zealand, Australia, etc. Its winds, currents and passages.* 4th edition, Richard Holmes Laurie, London.

Long Island, in lat. 5°20′S long. 147°10′E is divided by a deep valley into two parts. The southern portion rises to a high conical peak about 4,000 ft. high; the northern consists of three peaks grouped together, and not reaching to quite the same height as the southern. Crown Island, about 9 miles north-westward of Long Island, has rather a level summit, and is lower than Long, or Rich Island.

Finsch, O., 1885a. *Reise nach Neu Guinea. Nachrichten über Kaiser Wilhelms-Land und den Bismarck-Archipel.* Neu Guinea Compagnie zu Berlin. Heft 2: 4.

On Oct 10 [1884] we travelled along the north coast of Crown Island, which has the form of a conspicuous, thickly wooded mountain approx. 1500′ high; neither coconut palms nor traces of people were to be seen. Long Island and Dampier Island [Karkar I], as well as Rich Island we saw from afar. All are thickly wooded. Here there are reefs everywhere, so that sailors must be very careful.

Finsch, O., 1885b. *Aus den Berichten des Dr. Finsch über die im Auftrage der Compagnie nach Neu Guinea ausgefuhrten Reisen. Nachrichten über Kaiser Wilhelms-Land und den Bismarck-Archipel.* Neu Guinea Compagnie zu Berlin. Heft 3: 5.

On the 29th [November, 1884] we travelled along the SE coast of Long Island as Dampier Strait is very dangerous because of many reefs and we had realized for a long time that one could put little or no trust in the charts. Long Island is mostly thickly wooded or covered with scrub and has no coconut palms or people; or at least it is very thinly peopled, for we saw only 2 or 3 small settlements in inaccessible bays whose inhabitants came offshore in a canoe and were difficult to persuade to come closer. The island has no harbours and hardly any anchorages.

Finsch, O., 1888a. *Samoafahrten. Reisen in Kaiser Wilhelms-Land und Englisch-Neu Guinea in den Jahren 1884 u 1885 an Bord des Deutschen Dampfers "Samoa".* Hirt und Sohn, Leipzig: 188-189.

Good physical description of Long Island as seen from the sea. Vegetation described as thinner than that on Karkar Island. Describes trade with the people of Long Island and some of their artefacts. Full translation in Ball, 1982.

Finsch, O., 1888b. *Ethnologischer Atlas: Typen aus der Steinzeit Neu-Guineas-Samoafahrten von Dr. O. Finsch.* Hirt und Sohn, Leipzig. 27; 35; 36; Plate VI-6; Plate VIII-1 & 2; Plate XVIII-4; Plate XXII-1 & 2.

Gives drawings and discussion of canoe ornaments, bracelets and 'war ornaments' from Long Island.

Finsch, O., 1891. Ethnologische Erfahrungen und Belegstücke aus der Südsee. Zweite Abtheilung: Neu-Guinea. *Annalen des K. Naturhistorischen Hofmuseums,* Band VI, Heft 1: 41.

Those 3 ethnological sections comprise the following areas:

(1) Mitrafels to Cap Croissilles and Karkar along with the other islands (Long, Rook), the French Islands, as well as the whole of western New Britain (I pages 117, 120, 121) except for the Gazelle Peninsula. The following things are characteristic for this eastern region: particular shape and decoration of certain bracelets (Plate III, Fig. 20, 21) and chest ornaments (Plate III, Fig. 23); hair combs of bamboo; frequent usage of dogs teeth; strange (particular) braided objects of yellow stained plant fibres (Plate XXII, Fig. 3), a unique head covering (cap of tapa and hair); much wood carving (headrest benches, Plate XVIII, Fig. 1, 2), a particular kind of shield (Plate XXIV, Fig. 1, 2); little nose decoration; broad, particularly very artistically engraved tortoise-shell bracelets.

Fisher, N. H., 1939. Report on the volcanoes of the Territory of New Guinea. *Geological Bulletin 2 (Administration of the Territory of New Guinea).* Commonwealth Government Printers, Canberra: 5.

Very brief discussion of the structure of Long Island. No trace of volcanic activity on the island in 1939.

Fisher, N. H., 1940. The volcanoes of the mandated Territory of New Guinea. *Proc. 6th Pacific Science Congress.* University of California, Berkeley, Vol. 2: 889-94.

Long Island, or Arop, has a large central crater lake about 6 by 8 km (4 by 5 mi.) in extent and 150 m (500 ft) above sea level with extinct cones up to 1200 m. (4000 ft) in height at the northeast and southwest ends. Crown Island is a thickly timbered remnant of a volcanic cone.

Fisher, N. H., 1957. *Catalogue of the active volcanoes of the world. Part V. Catalogue of the active volcanoes and solfatara fields of Melanesia.* International Volcanological Assoc., Naples: 12-13.

Summarizes knowledge of geology of Long Island, and briefly describes the eruptive activity of 1953-55.

Gill, G. H., 1968. *Australia in the War of 1939-45. Navy. Royal Australian Navy, 1942-1945.* Australian War Memorial, Canberra: 270-273, 344.

Describes destruction, in the Vitiaz Strait and Huon Gulf, of a large Japanese convoy sent from Rabaul to strengthen the garrison at Lae in March 1943. Brief description of the occupation of Long Island by Allied forces in December 1943.

Great Britain, Hydrographic Office, Dept. of the Admiralty, 1933, 1946, 1971. *Pacific Islands Pilot. Vol. 1. The Western Groups and the North Coast and Southeast Part of New Guinea.* Hydrographer of the Navy, Taunton, 6th (222), 7th (241-242) and 9th (246) editions.

Brief description of Long Island and its surrounding waters. The 7th edition, 1946, gives the population in 1932 as 230 persons.

Groves, W. C., 1934. The natives of Sio Island, southeastern New Guinea: a study in culture contact. *Oceania* 5: 43-63.

Sio village on the north coast of the Huon Peninsula trades with, and supplies missionaries to, Long Island. The Sio formerly used flakes of obsidian 'from Siassi and Arop' to shave children's heads. Some betel nut mortars 'carved in the form of grotesque human figures, and said to be of Arop Island origin, are of particular interest from the artistic point of view.'

Hagen, B., 1899. *Unter den Papuas. Land und Leute, Thiere und Pflanzen in Deutsch Neu-Guinea.* C. W. Kreidel's Verlag, Wiesbaden.

Text mentions only that Long Island is one of a string of islands off the north coast, and was sighted from a mountain inland behind Stephansort. Appendix gives Kilibob-Mandumba legend in a version similar to, but more complete than, that in *Deutsche Kolonialzeitung* for 1897.

Hammer, K. L., 1907. *Die geographische Verbreitung der vulkanischen Gebilde und Erscheinungen im Bismarckarchipel und auf den Salomonen.* Dissertation zur Erlangung der Doktorwürde bei der philosophischen Fakultät der Grossherzoglich Hessischen Ludwigs-Universität zu Giessen. Munchow'sche Hof- und Universitats-Druckerei, Giessen.

Explains why Dampier gave the inappropriate name 'Long Island' to a circular island. States the island has three peaks: Reaumur in the north, Cerisy in the south, and Coriz in the west. Cerisy said to be the highest with an elevation of 609 metres. The peaks are described as part of an old crater wall.

Harding, T. G., 1967a. A history of cargoism in Sio, north-east New Guinea. *Oceania* 38: 1-23.

[8] The Sios also became energetic evangelists — the first party of mission helpers began work in Malalomai in 1925 — and they could later claim the eastern Rai coast and Arop Island as their own missionary field.

Harding, T. G., 1967b. *Voyagers of the Vitiaz Strait.* University of Washington Press, Seattle and London.

Describes voyages by Long Islanders and trade between them and the inhabitants of neighbouring islands. Quoted extensively in Ball (1982), Ball and Hughes (1982).

Heavey, W. F., 1947. *Down Ramp!* Infantry Journal Press, Washington, D. C.

Describes occupation of Long Island by Allied troops in December 1943. Similar coverage in U.S. Army, Second Engineer Special Brigade (1946) and in U.S. Army, Office of the Chief Engineer GHQ (1959).

Hornabrook, R. W., 1974. The demography of the population of Karkar Island. *Phil. Trans. R. Soc. Lond.* B. 268: 229-39.

[230] Average annual population increase for Long Island said to be similar to the 1.86% recorded in Karkar between 1925 and 1939.

Hunter, R. L., 1841. Eastern Dampier Strait. *The Nautical Magazine and Naval Chronicle* 10: 743-45.

According to Wichmann (1909, 50) Hunter sighted Long Island in 1840 and stated that whalers called it Crown Island.

Johnson, R. W., 1970. Seismicity in the Bismarck Volcanic Arc. *Bur. Miner. Resour. Aust. Rec. 1970/35.* Unpublished.

Long Island was a centre of deep-focus earthquakes during 1958-69.

Johnson, R. W., 1976. Late Cainozoic volcanism and plate tectonics at the southern margin of the Bismarck Sea, Papua New Guinea. In R. W. Johnson (ed.), *Volcanism in Australasia.* Elsevier, Amsterdam: 101-16.

Long Island is in the western of two late Cainozoic volcanic arcs at the southern margin of the Bismarck Sea. This western arc is associated with the boundary between the south Bismarck and Indo-Australian plates.

Johnson, R. W., G.A.M. Taylor, and R. A. Davies, 1972. Geology and Petrology of Quaternary Volcanic Islands off the North Coast of New Guinea (including an Appendix on the 1968 eruption of Long Island, by G. W. D'Addario). *Bur. Miner. Resour. Aust. Rec. 1972/21.* Unpublished.

At the time of its compilation, this was the most complete summary of Long Island geology. Now partially superseded by Ball and Johnson (1976), Blong, Pain and McKee (1982), and Pain, Blong and McKee (in press).

King, F. J., 1844. Navigation through St. George Channel to the westward towards the coast of New Guinea. *The Nautical Magazine and Naval Chronicle* 13: 12-13.

Antediluvian Island — 6th, made a round island about two miles in circumference, surrounded by a reef which stretched to the south-east towards Long Island, on which the Lady Blackwood struck in 1840, making a passage between the two islands. This island I called Antediluvian Island, and is uninhabited; by good observations is in lat. 5°45′ south, long. 146°50′ east. The abovenamed islands and reefs are not layed in Horsburgh's, Norie's, or any charts on board the Waterwitch, or any I have hitherto seen.

Kisokau, K., 1974. Analysis of avifauna stomach contents of Long and Crown Islands, Madang District. *Science in New Guinea* 2(3): 261-62.

Lists gut contents of nine species of Long Island and Crown Island birds.

Lawrence, P., 1964. *Road Belong Cargo: a study of the cargo movement in the Southern Madang District, New Guinea.* Manchester University Press, Manchester: 268.

Cult leader Yali said by his followers to have caused the 1953 eruption on Long Island by invoking the local deities in order to express his hatred of Europeans.

Lincoln, P. C., 1976. Rai Coast Survey: First Report. Univ. of Papua New Guinea seminar paper (to appear in *Univ. of Hawaii Working Papers in Linguistics*).

States that the languages spoken in Malasanga, Singorakai and Sel could be treated as a single language and that, 'Various informants, particularly Henry Korim of Lokep, insist that the speech varieties of Lokep Is. [Tolokiwa], Arop Is., and Barim on Umboi Is. are also dialects of this same language.' Continues, 'In other words, without regurgitating the red herring of language vs. dialect, we can say that Sel, Arop, Lokep, Barim, Malasanga and Singorakai are closely related and in fairly recent times were a single speech community: we can call this the *Korap* subfamily after a distinctive word for "man" found in mainland varieties.'

Lincoln then goes on to hypothesize, on the basis of the distribution of the Korap subfamily, that in the past a third trading network existed between the Biliai trade network (centred on Madang) and the Siassi trade network.

Lincoln, P. C., 1977. Subgrouping across a syntactic isogloss.
Unpublished MS, presented at Austronesian Symposium of Linguistic Society of America Linguistic Institute, Honolulu, Hawaii, August 1977.

Only addition to 1976 paper that relates directly to Long Island is the surprising statement that Lokep and Sel materials share only 55% cognates. Quotes a Lukep [Lokep] Islander as saying that some members of the Lukep population 'speak somewhat differently' than others. It was the informant's opinion 'that the Lukep [Lokep] varieties including Arop, Sel, Barim, and Malasanga including Singorakai would all turn out to be mutually intelligible.' As pointed out by Lincoln, further work is clearly needed.

Lindgren, E., 1975. *Long Island – A Preliminary Land-Use Plan.* Dept. of Agriculture, Stock and Fisheries, Port Moresby. Unpublished.

Previous to this series of papers (i.e. Specht et al., 1982; Blong, Pain and McKee, 1982; Egloff and Specht, 1982; Ball, 1982; Ball and Hughes, 1982) the most complete source of general information about the island. Proposes that Long Island be made a National Park and makes management proposals. Contents include:

1. Preamble
2. A Management Plan
3. Overall Considerations
4. References
5. Appendices
    a. Preliminary report-Lindgren 1973
    b. A reconnaissance survey-Miniotas 1973
    c. Long Island — a survey — Ball 1974
    d. List of the island fauna
    e. Map of proposed land use

Malcolmson, L. F. (ed.), 1975. *National Fisheries School – Madang Province – Fisheries Survey 1975.* Roneoed. Department of Agriculture, Stock and Fisheries, Madang.

Description of traditional fishing rights and their establishment; Bok, Kaut and Matapun have rights to the southern part of the island from Biliau on the west to the stone island on the east; Poin Kiau and Malala have rights to the northern part of the island between Biliau and the stone island as well as to Crown Island and the surrounding reefs. Everyone on the island is said to know these boundaries so that problems arose only when Franz Moeder picked up people from one side of the island and used them to collect shells all the way around the island. Moeder was paying 3t/lb for trochus in 1975. Turtles on Long Island are said to be of three types; those with a soft skin — *olol*, those with a medium skin — *padodo*, and those with a hard skin — *kavariu*. The local name for turtle is *pon*. *Kavariu* is the biggest of the turtles. Turtles are said to be easily caught and the only problem in marketing them is transport. The people of Long Island handline only for immediate consumption. Matapun, Poin Kiau, and Malala all have good beach-netting areas. A canoe census of Long Island found 14 big (12-15′) canoes at Matapun, 30 big canoes at Bok and Kaut, 6 small (7′) canoes at Poin Kiau, and 20 big and 5 small canoes at Malala.

The names of many species of fish in the local language were collected at Malala village and are given together with their equivalents in New Guinea Pidgin and English.

Manser, W., 1974. *Earth Science Abstracts, Papua New Guinea, to 1971.* Australian Government Publishing Service, Canberra.

Lists papers dealing with the geology of Long Island. Includes a few brief reports on volcanic and earthquake activity not included here. Entry 01-a-39 erroneously states that D'Entrecasteaux saw Long Island erupting in June 1793. This account clearly refers to an eruption of Ritter Island.

Manser, W. and N. M. Reynolds, n.d. (1976?) Earth Science Abstracts 1972-73. *Geological Survey of Papua New Guinea Memoir 4,* Port Moresby.

Lists papers dealing with the geology of Long Island. Includes a few brief reports on earthquake activity not included here.

Manser, W., 1978. Earth Science Abstracts 1974-76. *Geological Survey of Papua New Guinea Memoir 5,* Port Moresby.

Lists papers dealing with the geology of Long Island. Includes a few brief reports on earthquake activity not included here.

McAlpine, J. R., G. Keig and K. Short, 1975. Climatic tables for Papua New Guinea. *Div. of Land Use Research Technical Paper* No. 37. CSIRO, Melbourne.

Summary of Papua New Guinea weather information. Does not contain data for Long Island, but still the most useful available source as it does contain data for such nearby localities as Gizarum (on Umboi Island) and Saidor.

McElhanon, K. A., 1978. *A classification of the languages of the Morobe Province, Papua New Guinea, with the linguistic situation of individual villages.* Dept. of Linguistics, Research School of Pacific Studies, Australian National University, Canberra.

Contains a map on which the *Lukep* language is shown as being spoken on northwest Umboi, Tolokiwa, and Long Island.

Mennis, M., 1978. The existence of Yomba Island near Madang: fact or fiction. *Oral History* 6: 2-81.

Contains numerous interviews with Austronesian speakers from the vicinity of Madang, many of whom trace their ancestry to the island of Yomba which supposedly once existed off Madang, perhaps on the site of what is presently Hankow Reef. All of those interviewed agreed that Yomba blew up and disappeared before Arop erupted, and many of the interviews give details of the latter eruption. A time of darkness associated with the eruption of Arop was reported as lasting for differing periods, the maximum being three days. The ash fall from Arop was heavy enough to ruin the gardens and cause a time of famine. Some reported that earthquakes and tidal waves were associated with the eruption, while others denied this.

Morgan, W. R., 1966. A note on the petrology of some lava types from east New Guinea. *J. Geol. Soc. Aust.* 13: 583-591.

Gives a few brief comments about Long Island petrology and includes chemical analysis of one specimen of augite andesite from the east caldera wall.

Moore, W. U. to Captain Bridge, 1885. *Supplement to the New South Wales Government Gazette No. 123,* Monday, 23rd March, 1885: 2006-09.

Description of the itinerary of the "Dart" and of hydrographic conditions encountered during the cruise to declare portions of New Guinea (including Long Island) a British Protectorate in 1885. Contains no information not contained in Bridge (1885).

Morrell, A., 1833. *Narrative of a Voyage to the Ethiopic and South Atlantic Ocean, Indian Ocean, Chinese Sea, North and South Pacific Ocean in the years 1829, 1830, 1831.* J. and J. Harper, New York: 77.

On the 12th of November we left Dampier's Island [Karkar], with fair weather and a fine breeze. We sailed at the rate of thirteen miles an hour, assisted by the current, and soon reached the north of Long Island, which is less elevated than the one we had just left. We saw only a few wigwams along the shore, and some natives; but we could not conveniently land, and kept on our course until we had passed the western end of Long Island, and thence proceeded to the coast of New Guinea.

Morrell, Capt. B. Jr., 1832. *A narrative of four voyages to the South Sea, North and South Pacific Ocean, Chinese Sea, Ethiopic and Southern Atlantic Ocean, Indian and Antarctic Ocean from the year 1822 to 1831.* J. and J. Harper, New York: 459.

I have introduced the foregoing particulars in this place, because the reader is now to be informed, that on the 12th of November, at five, P.M., the Antarctic was on her way to this coast, from Dampier's Island [this must refer to Umboi judging by the direction Morrell was sailing, although most charts at this time applied the name Dampier's Island to the island now known as Karkar — R. J. S. Cooke, pers. comm.] sailing at the rate of thirteen miles an hour, on a sea which was smooth as a mill-pond, rendered so by the current that set through the strait towards the north-west, at the rate of four miles an hour. At six, P.M., we were within one mile of the north shore of Long Island, which is about the same size as the one we had just left, Dampier's Island, but not so much elevated. We saw a few scattering huts along the banks of the seacoast, and a number of natives about them, who made signals for the vessel to stop. But the wind coming off from the land in strong gusts, and wishing to get clear of the island before dark, we continued our course to the westward, until we had cleared the western end of Long Island; when we immediately hauled in to the south, for the north-east of New Guinea, or the island of Papua.

I feel it a duty in this place to put mariners on their guard, by stating that there are many dangerous coral reefs around the two last-mentioned islands; some of which extend several miles into the sea.

Naval Intelligence Division, 1945. Pacific Islands, Vol. IV Western Pacific (New Guinea and Islands Northward). *Geographical Handbook Series B. R.* 519C: 42, 60.

Summary of Long Island geography. In one place the last major eruption which killed all the inhabitants is said to have occurred 150 years ago; in another place this event is said to have occurred 'three centuries ago'.

Oldfield, F., P. G. Appleby and R. W. Battarbee, 1978. Alternative ^{210}Pb dating: results from the New Guinea highlands and Lough Erne. *Nature* 271: 339-342.

On the basis of a new assumption (constant rate of supply as compared to constant initial concentration) ^{210}Pb dates for the Long Island eruption were changed from 1860 to 1814. However, further more recent changes in assumptions by the same authors give a date of 1685 (R. J. Blong, pers. comm.).

Pain, C. F. and R. J. Blong, 1979. The distribution of tephras in the Papua New Guinea highlands. *Search* 10: 228-230.

Contains a map showing the distribution in the New Guinea highlands of the Tibito Tephra, which originated from an eruption of Long Island. The text states (p. 229):

The youngest tephra, Tibito Tephra, contains an area of at least 87,000 km^2 within the 1.5 cm isopach. This unit was erupted from Long Island 150 km east of Madang >300 years ago (Blong, in prep.).

Pain, C. F., R. J. Blong and C. O. McKee, in press. Pyroclastic deposits and eruptive sequences on Long Island, Papua New Guinea. *P.N.G. Geol. Surv. Memoir.*

The most detailed discussion of pyroclastic deposits and eruptive sequences on Long Island. Supersedes Johnson, Taylor and Davies (1972) and Ball and Johnson (1976).

Papua New Guinea Government — Area Study; Long Island 1969, Bailey, G. E.

See below.

Papua New Guinea Government — Area Study; Long Island 1973, Creagh, R. B.

See below.

Papua New Guinea Government — Area Study; Long Island 1974, Spencer, J. B.

These unpublished government documents are among the most valuable sources of information about Long Island since they cover all aspects of life on the island. They were written by whoever was in charge at Saidor.

Papua New Guinea Government — Drought Survey Report — Long Island — N. Owet, Saidor; 1 November, 1972.

All villages on the island were visited, gardens were inspected and the drought problems and food shortage were discussed with the people. No immediate relief was felt to be necessary, although it was felt that the government might need to supply rice before the gardens were again producing. The abundance of protein available to the islanders was noted.

Papua New Guinea Government — Patrol Report — Anonymous, Saidor 4 of 1951/52.

The following excerpt from this report was supplied by Mr. R. B. Creagh while he was ADC, Saidor:

People very natural and eager to please and most hospitable to the patrol. Apparently this has not always been the case, because the O.I.C. was presented with a piece of grapeshot that had fallen from a dead tree — possibly the mark of a visiting ship early in the last century.

Papua New Guinea Government — Patrol Report — Bailey, G. E., Saidor 4 of 69/70.

Contains sections on Cargo Cult activities, an abortive promotional visit to Long Island by a Pacific Islands Regiment Patrol and the failure of a naval vessel to pick up a medical case from Matapun as well as much material also in the 1969 Area Study.

Papua New Guinea Government — Patrol Report — Somers, P. J., Saidor 11 of 69/70.

This patrol visited the island in November, 1969, to set up copra driers in Matapun, Bok and Malala, to explain to the people the proposed plans for copra marketing, to initiate further new plantings of coconuts and to arouse enthusiasm for economic development. According to the report the first two objectives were accomplished while the other two would require follow-up work. The patrol report otherwise contains little information not in the Long Island Area Studies.

Papua New Guinea Government — Patrol Report — Bailey, G. E., Saidor 4 of 70/71.

The patrol discussed with the Long Islanders issuance of a prospecting authority (to whom or for what is not stated). Copra production is said to have increased somewhat since the driers were introduced. Long Island is suggested as 'an excellent site for a wildlife sanctuary.'

Papua New Guinea Government — Patrol Report — Apa, G., Saidor 1 of 1978.

The purposes of this patrol were to: (1) compile the new annual census register, (2) fill out a village survey questionnaire, (3) carry out routine administration, and (4) give talks on: (a) upkeep of the community workforce, (b) misinterpretation of Pono Wildlife Refuge rules, (c) business promotion, and (d) the virtues of newly introduced cash crops. Extensive report containing much information.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Thursday May 3, 1973. "A Long Island spectacular".

Much of this issue describes the eruption of Motmot on May 2, 1973.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Friday May 4, 1973. "Plane crashes near volcano. 3 survive".

Description of the ditching in Lake Wisdom of a Cessna 185 piloted by Richard Leahy during a flight to view the eruption of Motmot.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Monday May 7, 1973. "Volcano still erupting".

A further brief report on the continuing eruption of Motmot.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Monday August 20, 1973. "Plane afloat at last".

Describes recovery, by SCUBA divers, of Richard Leahy's Cessna 185 from a depth of approximately 30 m in Lake Wisdom.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Friday March 5, 1976. "Our National Parks: Each area is different".

Description of the attractions of Long Island as a proposed National Park.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Sept. 1976. Independence First Birthday Souvenir Issue, "Progress Smooth".

Discussion of Madang Province includes the following:

Then there is the Long Island (Saidor District) wildlife reserve for turtles which is gradually becoming well-known. Living in the lake in the middle of a volcano in the centre of the islands is a species of turtle unique in the world. We are trying to get the place made a reserve. Catching the turtle is already restricted to local people, Mr Koibo said.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Friday Oct. 28, 1977. "Tago pushes for gun laws".

Mr Tago said Long Island people had agreed to control their use of shotguns so they did not kill all the animals on Crown and Long Islands.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Friday May 25, 1979. "Madang's volcanic islands".

Excellent popular summary of the volcanic history of Long, Karkar and Manam Islands.

Papua New Guinea Post Courier (Newspaper), Port Moresby, Friday June 15, 1979. "Yomba-PNG's Lost Atlantis".

Greatly abbreviated version of the information given by Mennis in *Oral History* 6: 2-81. Contains several mentions of Long Island.

Parfitt, R. and A. D. Thomas, 1975. Phosphorus availability and phosphate fixation in Markham Valley soils. *Science in New Guinea* 3(2): 123-130.

Considers Long Island a possible source for unusual components of an ash soil at Umi, in the Markham Valley.

Powell, W., 1884. Visits to the Eastern and North-eastern Coasts of New Guinea. In: Further Correspondence Respecting New Guinea, The New Hebrides, and other islands in the Pacific *(In continuation of (C. 3691) July 1883, and (C. 3814) August 1883).* Colonial Office, London. Pp. 13-19.

Cook Island is extinct, but has the appearance of not having been long so; as are also the craters of Lottin, Long and Crown Islands.

Reche, O., 1914. Dampier's Route längs der Nordküste von Kaiser-Wilhelms-Land. *Petermann's Geographische Mitteilungen* 60: 223-225.

Deals mainly with the identity of Karkar and Bagabag Islands, but useful for sorting out Dampier's figures of other islands on the north coast of New Guinea as well.

Reche, O., 1918. Abel Janszoon Tasman's Reise längs der Küste von Kaiser Wilhelms-Land im Jahre 1643. *Mitteilungen der geographischen Gesellschaft in*

Hamburg 31: 195-196.

Reche feels that Tasman saw both Crown and Long Islands in 1643, but that he mistook the latter for part of the mainland.

Reche, O., 1954. *Nova Britannia. Ergebnisse der Südsee Expedition 1908-1910.* II Ethnographie. A. Melanesien, Band 4, 1 Teilband. Ludwig Appel, Hamburg. 18: 89-90.

Repeats claim that Tasman saw Long Island in 1643. Gives very useful account (with photos) of people and conditions encountered during a one-day visit to Long Island in May, 1909. A full English translation is given by Ball (1982).

Reina, P., 1858. Ueber die Bewohner der Insel Rook, östlich von Neu-Guinea, nebst einigen Notizen über Neu-Guinea und benachbarte Inseln. *Zeitschrift für allgemeine Erdkunde (N.F.)* 4: 353-365.

Account of Father Paul Reina's stay (1852-55?) on Umboi Island as a missionary for the Institute of Foreign Missions of Milan. There are discrepancies in different accounts concerning the period which the missionaries actually spent on Umboi. Most accounts state that they left in 1855 or 1856, but this paper seems to indicate that Reina was still there in 1857. The only mention of Long Island is:

> The people said that 25 or 30 years before (that is, when the approximately 40 year old son of an old headman was a boy) a ship appeared from [the direction of ?] Long Island, an island lying between Rook and New Guinea, against whose crew the inhabitants made a fierce attack, so that one of the white men was wounded in the eye. At this the white men landed, burned down a village and killed the inhabitants.

Riesenfeld, A., 1950. *The Megalithic Culture of Melanesia*. E. J. Brill, Leiden: 362-370, 671-673.

After reviewing myths and legends relating to Long Island (taken mainly from Bamler [1911] and Hagen [1899]) he proposes to identify two migrations to the island: one from Karkar via Astrolabe Bay, the other via Rook (Umboi) Island.

Robson, W., 1911. *James Chalmers – Missionary and Explorer of Rarotonga and New Guinea.* New Edition. S. W. Partridge and Co. Ltd., London.

Mentions Chalmers' visit to Long Island on *H.M.S.* Dart in 1885.

Salomonsen, F., 1966. Preliminary descriptions of new honey-eaters (Aves, Meliphagidae). *Breviora Mus. Comp. Zool. (Harvard).* No. 254: 1-12.

[3] Describes a new subspecies of honey-eater, *Myzomela nigrita nigerrima,*from Long Island.

Sapper, K., 1910. Beiträge zur Kenntniss Neupommerns und des Kaiser-Wilhelms-Landes. *Petermann's Geographische Mitteilungen* 56: 256.

Long Island has, at the north and south ends, a high and no longer active volcano.

Schleinitz, G. E. G., Frhr. von, 1889. Beschreibung der Nordküste von Kaiser Wilhelms-Land von Kap Cretin bis zu den Legoarant-Inseln. *Nachrichten über Kaiser Wilhelms-Land und den Bismarck-Archipel.* Neu-Guinea Companie zu Berlin. 5: 48-87.

[86] Long Island, an island of smoothly rolling hills, has at each end conical mountains with double peaks, which are presumably the remnants of destroyed crater walls. According to the British Admiralty Charts the island has three such mountains; however, on many passages, admittedly at a great distance, only two peaks have ever been visible, of which the northern and western appear very similar regardless of the direction of viewing. It is, therefore, not unthinkable that the island has only two higher peaks.

Schmitz, C. A., 1959. Zur Ethnologie der Rai-Küste in Neuguinea. *Anthropos* 54: 27-56.

Includes much information about Austronesian cultures on the mainland coast opposite Long Island. Speculates that Long Island has become the cultural centre for the Austronesian-speaking peoples of the north coast of New Guinea.

Schmitz, C. A., 1960. *Historische Probleme in Nordost-Neuguinea – Huon Halbinsel. Studien zur Kulturkunde 16.* Franz Steiner Verlag, Wiesbaden.

Surveys the cultural elements of the peoples of north-east New Guinea and speculates on their origins. The people of Long Island are attributed to the Austronesian 'Kultur C', the most recent of three migrations.

Shaw, H. J. Jr. and D. T. Kane, 1963. *Isolation of Rabaul. History of U.S. Marine Corps Operations in World War II,* vol. II. Historical Branch G-3 Division Headquarters U.S. Marine Corps. U.S. Government Printing Office, Washington.

Brief description of the occupation of Long Island by Allied Forces in 1943.

Specht, J., E. E. Ball, R. J. Blong, B. J. Egloff, I. M. Hughes, C. O. McKee, and C. F. Pain, 1982. Long Island, Papua New Guinea — An Introduction. *Rec. Aust. Mus.* 34(6): 407-417.

Introduction to a series of papers about Long Island (Blong, Pain and McKee, 1982; Egloff and Specht 1982; Ball 1982; Ball and Hughes 1982) describing how the papers come to be written and including a general description, with photographs, of the island.

Taylor, G. A. M., 1953. Notes on Ritter, Sakar, Umboi and Long Island Volcanoes. *Bur. Miner. Resour. Aust. Rec. 1953/43.* Unpublished.

Useful description of Long Island, its geological history and its inhabitants. Motmot was not visible in 1952.

Taylor, G. A. M., 1954. Review of Volcanic activity in the Territory of Papua New Guinea, the Solomon and New Hebrides Islands 1951-53. Australian National Committee on Geology and Geophysics. Report of the Sub-Committee of Vulcanology 1953. *Bur. Miner. Resour. Aust. Rec. 1954/28.* Unpublished.

Account of the 1953 eruption of Motmot. Best's account (1956a, 1956b) is more complete with the exception of the following:

The crater was inactive when examined on 12th June. Spasmodic activity continued, however, during the following months. The last outburst was reported on 7th January, 1954.

Taylor, G. A. M., 1956. Review of Volcanic activity in the Territory of Papua New Guinea, the Solomon and New Hebrides Islands, 1951-53. Australian National Committee on Geology and Geophysics. Report of the sub-committee on Vulcanology, 1953. *Bulletin Volcanologique*. Série II, Tome XVIII. Naples.

Identical to Taylor, 1954.

Territory of Papua and New Guinea, 1969. *Geological and Volcanological Branch – Summary of Activities – 1968.* Department of Lands, Surveys and Mines, Port Moresby. Unpublished.

Describes the 1968 eruption of Motmot. D'Addario provides a fuller account in an appendix to Johnson, Taylor and Davies (1972).

Thilenius, G., 1927. *Ergebnisse der Südsee-Expedition 1908-10.* I. Allgemeines. L. Friederichsen and Co., Hamburg: 151-153.

Describes 'Südsee-Expedition' visit to Long Island in 1909 which Reche (1954) also describes. The two accounts differ and are complementary. A full translation is given in Ball (1982).

U.S. Army. Office of the Chief Engineer, General Headquarters Army Forces, Pacific, 1959. Amphibian Engineer Operations. Vol. IV in *Engineers of the Southwest Pacific 1941-1945. Reports of operations United States Army Forces in the Far East. Southwest Pacific Area. Army Forces, Pacific.* Government Printing Office, Washington, D.C.: 181.

The most complete account of the Allied occupation of Long Island in December, 1943, and subsequent activities.

U.S. Army. Second Engineer Special Brigade. 1946. *History of the Second Engineer Special Brigade. U.S. Army World War II.* Telegraph Press. Harrisburg, Pa.

Detailed account of the occupation of Long Island by Allied troops in December, 1943.

Vogel-Hamburg, H., 1911. *Eine Forschungsreise im Bismarck Archipel: bearbeitet von H. Vogel-Hamburg . . . mit einer Einführung von G. Thilenius.* L. Friederichsen and Co., Hamburg.

Popular account by another member of the 1908-1910 'Südsee-Expedition'. A short visit was made to Long Island. A feast at Sikawa village on Sio Island was attended by 'magnificently decorated inhabitants of Long Island whose villages have unfortunately remained hidden from us.' A map shows Long Island with three peaks but no central lake.

Wichmann, A., 1909. *Nova Guinea – Résultats de l'Expédition Scientifique Néerlandaise à la Nouvelle-Guinée en 1903 sous les auspices de Arthur Wichmann.* Vol. 1. Entdeckungsgeschichte von Neu-Guinea (bis 1828).

Excellent thorough summary of early exploration in New Guinea with brief mention of Long Island and descriptions of early explorers who sighted the island.

Wichmann, A., 1910. *Nova Guinea – Résultats de l'Expédition Scientifique Néerlandaise à la Nouvelle-Guinée en 1903 sous les auspices de Arthur Wichmann.* Vol. 2 part 1. Entdeckungsgeschichte von Neu-Guinea (1828-1885).

Continuation of the preceding volume covering the years 1828-1885.

Wichmann, A., 1912. *Nova Guinea – Résultats de l'Expédition Scientifique Néerlandaise à la Nouvelle-Guinée en 1903 sous les auspices de Arthur Wichmann.* Vol. 2 part 2. Entdeckungsgeschichte von Neu-Guinea (1885-1902).

Continuation of preceding volume covering the years 1885-1902.

Z'graggen, J. A.,1971. Classification and typological studies in languages of the Madang District, Papua New Guinea. *Pacific Linguistics Series C*, No. 19. Department of Linguistics, Research School of Pacific Studies, Australian National University, Canberra.

Calls the Long Island language Arop in the Vitiazan Sub-family of the Siassi Family of Austronesian languages.

Z'graggen, J. A., 1973. The languages of the Madang District, Papua New Guinea. *Pacific Linguistics Series D*, No. 25. Department of Linguistics, Research School of Pacific Studies, Australian National University, Canberra.

Language map which refers to the Long Island language as Arop in the Vitiazan Sub-family of the Siassi Family of Austronesian Languages.

Z'graggen, J. A., 1975. The languages of the Madang District, Papua New Guinea. *Pacific Linguistics Series B*, No. 41. Department of Linguistics, Research School of Pacific Studies, Australian National University, Canberra.

Arop is an Austronesian language in the Siassi Family, Vitiazan Sub-family. It is spoken by 966 people of whom 826 live on Long Island and 140 live on the mainland in the villages of Mur (100), Sel (40) and Seure (?). It is hypothesized that New Ireland is the point of departure for the Austronesian languages of the North Coast of New Guinea.

Z'graggen, J. A., 1976. Austronesian languages: Madang Province. In S. A. Wurm (ed., *New Guinea Area Languages and Language Study, Vol. 2. Austronesian Languages:* 285-298. Department of Linguistics, Research School of Pacific Studies, Australian National University, Canberra.

The Arop language is a member of the Vitiazan Sub-family of Austronesian languages spoken on Long Island and in parts of Mur and Sel villages on the mainland. There are said to be 966 speakers of Arop.

Manuscript accepted for publication 21 February, 1980

GUIDE TO AUTHORS

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(iii) A summary not exceeding either 3 per cent of the text or 200 words and intelligible to the reader without reference to the main text.

(iv) A list of contents may be included if the paper is very long.

(v) Introduction.

(vi) The main text of the paper.

(vii) Acknowledgements.

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Only the names of genera and species should be underlined. Unless indicated elsewhere in the text, or where nomenclature follows a generally accepted standard (which should be cited), the authority should be cited when any specific name is used for the first time.

In taxonomic papers the short form (taxon, author, date, page) should be used in synonymies and the full reference taken to the end of the paper. In synonymies a period and dash (—) should separate the name of the taxon and the name of the author except in the case of the reference to the original description. Where new species are described the location of the type material must be indicated and Article 73 and associated recommendations of the International Code of Zoological Nomenclature should be followed. Dichotomous keys with contrasting parts of couplets adjacent to each other are recommended. In these only the first part of the couplet should be numbered and the beginning of the second indicated with a dash at the left-hand margin. Keys must not use serially indented couplets. Papers not following this form of presentation will be returned to the authors.

Tables

Tables should be typed on separate sheets and numbered in Arabic numerals. Headings should be

A NEW SPECIES OF *LEIOLOPISMA* (LACERTILIA: SCINCIDAE) FROM WESTERN AUSTRALIA, WITH NOTES ON THE BIOLOGY AND RELATIONSHIPS OF OTHER AUSTRALIAN SPECIES

Allen E. Greer

The Australian Museum, Sydney

SUMMARY

Leiolopisma baudini n. sp. is described on the basis of a single specimen from the vicinity of Point Culver, Western Australia. The new species is quite distinct and relatively primitive. Its closest living relative appears to be *L. entrecasteauxii* from southeastern Australia. Brief notes are provided on certain aspects of habitat, female reproduction and colour hues of most of the mainland Australian and Tasmanian species of *Leiolopisma,* and these data are used to support Rawlinson's (1974b and 1975) suggestion that the Australian species of the genus, at least, form two subgroups. A key is also provided to the described species of *Leiolopisma* from mainland Australia and Tasmania.

INTRODUCTION

During the course of a botanical survey in the area just west of Point Culver, Western Australia in October 1973, Mr Michael J. Brooker collected a number of reptiles which were subsequently lodged in the Western Australian Museum, Perth. Among these was a single specimen of an undescribed species of *Leiolopisma*. I discovered this specimen in 1976 during the course of an examination of the skinks in the Western Australian Museum and the curator of that collection, Dr Glen Storr, has kindly allowed me to borrow the specimen in order to describe the species. The species is interesting for three reasons. First, it is only the second species of *Leiolopisma* to be discovered in Western Australia. Second, it appears to be one of the two most primitive species known in the genus (along with *L. spenceri* — see Greer 1974 and 1980). Third, it appears to form a species pair with *L. entrecasteauxii* from southeast Australia and with this species provides yet another example of speciation in a once continuously distributed mesic temperate population following the loss of connecting habitat at the head of the Great Australian Bight.

In describing the new species, I take the opportunity to publish a few personal observations on other Australian *Leiolopisma* and to offer additional evidence for dividing the Australian species into two groups (Rawlinson 1974b and 1975). I also provide an updated key to the species of *Leiolopisma* occurring on mainland Australia and Tasmania.

METHODS

Definitions of head scales follow Taylor (1935) except that the supraciliary scale row is taken to end with the last scale contacted by both the fourth supraocular and the palpebral row. The preoculars are indicated by small dots in Figure 1.

Records of the Australian Museum, 1982, **Volume 34 Number 12,** 549-573, Figures 1-7.

Paravertebral scales are counted from the first scale completely posterior to an imaginary line drawn along the posterior edge of the thighs (held perpendicular to the long axis of the body) forward to and including the anteriormost nuchal.

Subdigital lamellae are counted from the first enlarged scale just beyond the edge of the sole of the foot to and including the last scale on the toe.

Scale size (in *L. pretiosum)* is taken as the width of a typical mid-dorsal body scale.

The longitudinal stripes are described in terms of their relationship to the longitudinal scale rows at midbody. For these purposes the scale rows are numbered sequentially beginning with the paravertebral scale row and counting laterally.

Limbs are measured by extending the limb perpendicular to the body and holding it against the free end of a ruler with the end of the ruler in contact with the body at the axilla or base of the tail. The measurement includes the claw and is made to the nearest 0.5 mm. All measurements relate to specimens fixed in 10-20 percent formalin and stored in 75 percent ethanol.

For those species for which I collected a large number of specimens at a single locality without any conscious bias as to size or sex, I have allocated the individuals of both sexes to one of three maturity groups — immature, transitional or mature — by visual inspection of the gonad and, in females, the oviduct. This is an admittedly crude method of evaluating the state of maturity, but it led to very few equivocal cases. This was no doubt due to the apparent synchrony of many life history events in these temperate animals.

The method of statistical comparison of two regression lines follows Snedecor and Cochran (1969). All other statistical procedures follow Simpson, Roe and Lewontin (1960). The 0.05, 0.01 and 0.001 levels of significance are indicated by one, two and three asterisks, respectively.

Leiolopisma baudini n sp.

Figs 1-3

HOLOTYPE: Western Australian Museum R44969; collected "west of Point Culver", Western Australia at 124°32'E and 32°53'S by Mr Michael G. Brooker on 28 October 1973. Sex: male.

DIAGNOSIS: *Leiolopisma baudini* can be distinguished from all other species of *Leiolopisma* (*sensu* Greer 1974) by the following combination of characters: supranasal scales present; frontoparietal scales paired, and two anterior loreals, one above the other.

Leiolopisma baudini can be distinguished from all other Australian *Leiolopisma* except *L. coventryi, L. entrecasteauxii* and *L. spenceri* by the paired frontoparietals. It can be distinguished from *L. coventryi* by the presence of supranasals, two anterior loreals and striped colour pattern; from *L. entrecasteauxii* by supranasals, two anterior loreals and the light lateral line involving scale rows 5 and 6 (instead of rows 6 and 7), and from *L. spenceri* by the two anterior loreals, lower number of longitudinal scale rows at midbody (26 vs 37-48) and deep instead of depressed head and body.

DESCRIPTION OF HOLOTYPE: A moderately sized (SVL = 48 mm), olive-brown skink with moderately deep head and body and bluntly rounded snout, well developed pentadactyl limbs and distinct narrow dorsolateral and lateral light stripes.

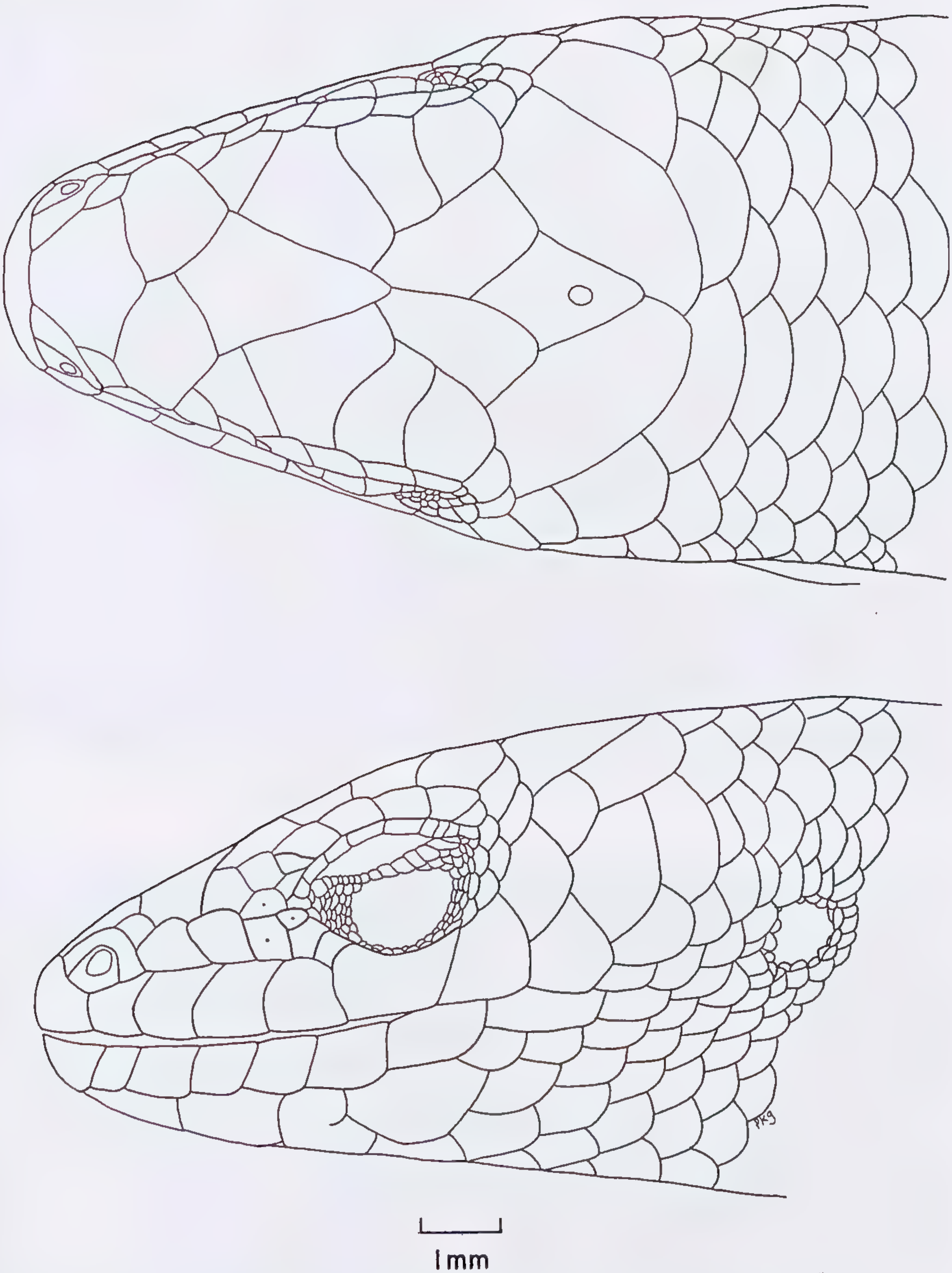

Fig. 1. Dorsal and lateral views of the head of the holotype of *Leiolopisma baudini* (W.A.M. R 44969). The preocular scales are indicated by small dots.

Rostral wider than deep, its suture with frontonasal virtually straight in dorsal view; frontonasal about one-and-two-fifths as wide as long, in contact with rostral for a distance equivalent to approximately one-third its maximum width; prefrontals large, in broad medial contact; frontal approximately one-and-a half times as long as wide; supraoculars four, anterior two in contact with frontal; frontoparietals and interparietal distinct, each frontoparietal as long as interparietal and slightly narrower, but all three scales approximately equal in area; parietal eye spot large, situated in posterior part of interparietal; parietals meet behind interparietal, left parietal contacted posterolaterally by two upper temporals and a nuchal and the right contacted by a single upper temporal and a nuchal; transversely enlarged nuchals, three on left side and two on right.

Nasal relatively small with nostril in posterodorsal corner; supranasals separated medially, each fused to postnasal to form a wide, strap-like scale bordering the nasal dorsally and posteriorly; two anterior loreals, upper approximately half size of lower; posterior loreal single, approximately equal in size to lower anterior loreal; preoculars three, anterior two largest, posterior one very small[1]; presuboculars two, subequal; supraciliaries 7-6; primary temporals 2-1; secondary temporals 2-2, each larger than any primary; supralabials 7-8, fifth and sixth situated below centre of eye on left and right sides, respectively; infralabials 7-7; postmental wider than long, in contact with first two infralabials on each side, followed by pair of chin scales in medial contact; lower eyelid movable with large clear window sharply delineated from uniformly small surrounding palpebrals; external ear opening circular, approximately one-third size of palpebral disc, without enlarged lobes or spines; tympanum moderately deeply sunk.

Scales mostly smooth but mid-dorsal body scales with two to three very low, broad, rounded "keels" or alternatively, with three to four striae; longitudinal scale rows at midbody 26; paravertebral scales 53; medial pair of preanals moderately larger than immediately adjacent preanals; each preanal overlaps scale medial to it and is in turn overlapped by scale lateral to it; fourth toe covered above by single row of scales and below by 22-23 smoothly rounded lamellae; scales in medial three rows of subcaudals subequal in size.

Snout-vent length 48 mm; tail length 55 mm, of which 35 mm is regenerated; length of fore and rear legs, 13 and 16 mm, respectively; limbs would overlap if adpressed to body.

Presacral vertebrae 28; phalangeal formula of manus and pes 2.3.4.5.3 and 2.3.4.5.4, respectively.

In preservative the ground colour is olive brown dorsally and pale bluish grey ventrally. A distinct white dorsolateral stripe begins on the mid-neck and extends posteriorly through the centre of the third midbody scale row and onto the base of the tail where it becomes diffuse. A similar lateral stripe begins on the posterior labials and extends posteriorly through the ear, above the insertion of the foreleg, through the lower part of the fifth and the upper part of the sixth midbody scale rows and ends abruptly at the rear leg. Dark brown pigment coalesces along the lateral edges of the six dorsalmost scale rows resulting in seven narrow and poorly defined dark longitudinal lines, the outer two of which on each side enclose the dorsolateral white stripe; similar dark lines run along the top half of the fifth longitudinal scale row and along the common border of the sixth and seventh scale rows to enclose the white lateral stripe.

[1]This small posterior preocular is fused to the lower (larger) of the two anterior preoculars in most specimens of *L. baudini's* close relatives, e.g. *L. entrecasteauxii* (Table 1).

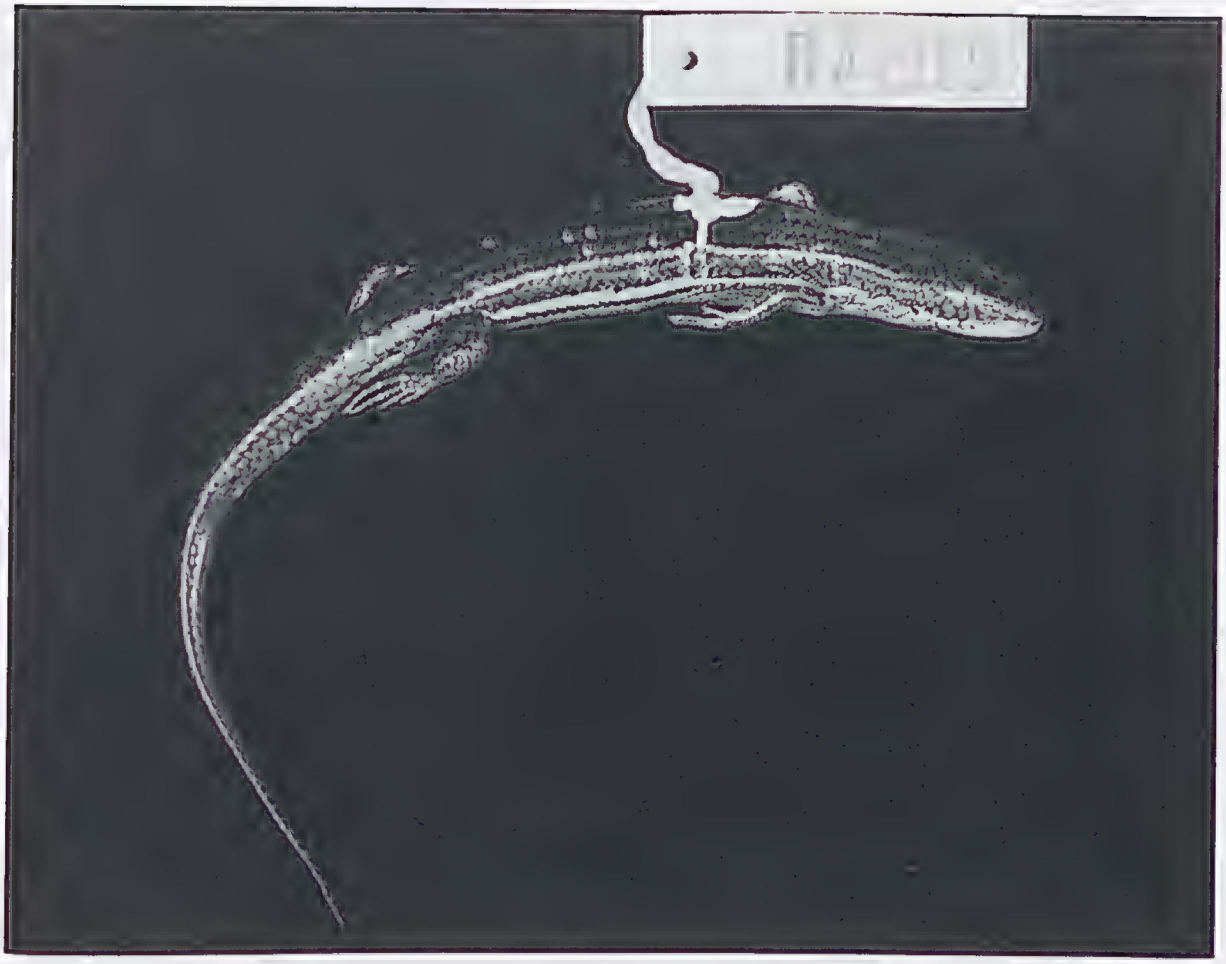

Fig. 2. The holotype of *Leiolopisma baudini* (W.A.M. R 44969). The SVL of the specimen is 48 mm.

Fig. 3. The head of the holotype of *Leiolopisma baudini* (W.A.M. R 44969).

TABLE 1. Comparison of certain morphometric and colour pattern characters in *Leioloposma baudini* and two of the most geographically proximate populations of its closest living relative *Leiolopisma entrecasteauxii.*

Character	*L. baudini* Western Australia N = 1	*L. entrecasteauxii* Eyre Peninsula and islands N = 6	Southeastern South Australia N = 31
Midbody scale rows			
Range	26	25-31	28-33
Mean	26	28.3	30.9
Mode	26	28,30	30
SD	—	1.86	1.11
Paravertebral scales			
Range	53	56-59	53-62
Mean	53	57.5	58.5
SD	—	1.05	2.55
Subdigital lamellae on fourth toe			
Range	22-23	18-24	17-23
Mean	22.5	21.2	20.7
SD	—	1.94	1.58
Supraciliaries			
Range	6-7	5-7	4-6
Mean	6.5	6.2	5.3
Mode	—	7	5
Snout-vent length (mm)			
Range	48	27-62	35-57
Frequency that small posterior preocular scale is distinct (see text)	1.00	0.33	0.03
Midbody scale rows covered by dorsal-lateral light stripe	3	3-4	3-4
Midbody scale rows covered by lateral light stripe	5-6	6-7	6-7

The top of the head is light olive brown with faint reticulations posteriorly. On the side of the head there is a very faint, diffuse brown streak just below the canthus, and the labials are immaculate except for one or two small brown spots posteriorly. The entire venter is immaculate.

HABITAT AND DISTRIBUTION: The only known specimen of *Leiolopisma baudini* was found on the ground in an open sandy area within a few feet of a vegetated dune immediately behind the beach in an area just west of Point Culver (Fig. 4). The vegetation was low (1 metre or less) and dense and consisted mainly of *Acacia cyclopis*, with some *Pimelea rosea* and *Scaevola crassifolia* (Mr Michael Brooker, pers. comm. in letter of 10 July 1978).

The type locality is just west of where the Baxter Cliffs swing inland to form the Wylie Scarp and the Israelite (coastal) Plain (Mr Michael Brooker, pers. comm. in letter of 22 November 1976) and in essence is at the extreme northern end of the Israelite Plain. Habitats similar to the type locality probably occur more or less continuously along the Israelite Plain to the south and perhaps also in several isolated siliaceous sand dune patches between Point Culver and Twilight Cove to the northeast (Nelson 1974). The area between Israelite Bay and Twilight Cove appears to be relatively little explored due to its inaccessibility, but if *Leiolopisma baudini* has a continuous distribution anywhere it is likely to be here.

ETYMOLOGY: The new species is named for Nicolas Baudin, Commander-in-Chief of a French voyage of discovery along the western and southern coasts of Australia between 1801 and 1803.

COMPARISON WITH SIMILAR SPECIES: *Leiolopisma baudini* is most similar to *L. entrecasteauxii* (Figs 5-6), a species that is widespread in southeast Australia including Tasmania and the islands of Bass Strait (Fig. 4). Both species have a short deep head and body, well developed limbs, and a dorsal colour pattern featuring light and dark longitudinal stripes (although the colour pattern may be subdued in some populations of *L. entrecasteauxii*). Both species also have distinct frontoparietals, a primitive feature that sets them apart from all other Australian *Leiolopisma* except *L. coventryi* which lacks light and dark stripes and *L. spenceri* which has a depressed body and a higher number of longitudinal scale rows at midbody (37-48 versus 25-33).

Leiolopisma entrecasteauxii has a wide geographic distribution and a broad habitat range and hence for the purposes of comparison, I have emphasized populations from the western part of the distribution. Unfortunately, however, *L. entrecasteauxii* appears to occur only in low densities in widely scattered populations in the extreme western part of the range, i.e. from the Coorong in South Australia west to Eyre Peninsula and its associated islands, and it is only in the extreme southeast corner of South Australia that one encounters the species in large numbers over wide areas. For the purpose of comparison, therefore, I have presented data (Table 1) for both the six specimens known from Eyre Peninsula and its associated islands and for 31 specimens from Beachport (N = 17) and Port Macdonnell (N = 14), the two largest samples available from southeast South Australia (see Specimens Examined section).

Table 1 shows that the Eyre Peninsula area specimens are morphometrically closer to *L. baudini* than are the specimens from southeast South Australia. This is especially evident in the number of midbody scale rows and the number of supraciliaries. The similarity is also evident in at least one other feature: the degree of separation between the nasal and postnasal. In the westernmost known specimen of *L.*

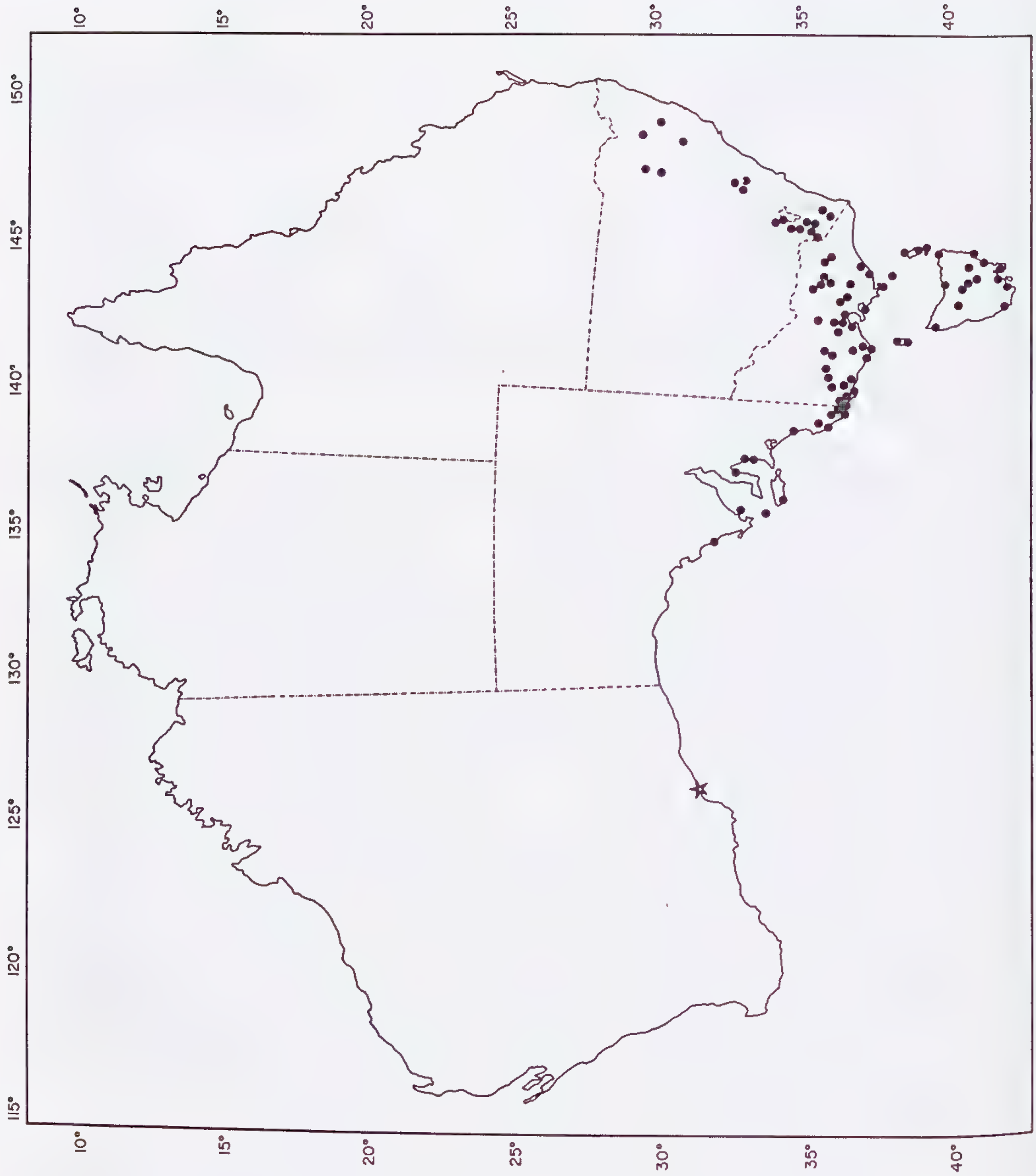

Fig. 4. Map of Australia showing the distribution of Leiolopisma baudini (star) and its nearest living relative L. entrecasteauxii (dots).

entrecasteauxii (from Pearson Island), the nasal is separated posteriorly from the postnasal by a well developed suture. This suture is also quite distinct, although often reduced in extent, in other Eyre Peninsula area specimens, but in the specimens from southeastern South Australia it is usually obscure or nonexistent. Despite the similarity between *L. baudini* and the westernmost *L. entrecasteauxii*, the new species can be distinguished from both these and other *L. entrecasteauxii* by its distinct supranasals and two anterior loreals and perhaps also by its broadly meeting prefrontals and the position of the dorsolateral and lateral light stripes.

Superficially *L. baudini* might be confused with either *L. trilineatum* or *L. duperreyi* (the recognition of this species is justified below) as both taxa have a deep head and body and some degree of light and dark striping. *L. baudini* differs from these two species, however, in having distinct supranasals, two anterior loreals, paired instead of fused frontoparietals, and a shorter body.

RELATIONSHIPS: The closest living relative of *Leiolopisma baudini* is probably *L. entrecasteauxii*. The basis for this presumed relationship is a difficult to quantify, but nonetheless immediately recognizable, similarity in size, shape and colour pattern. Both species, for example, have a short deep head and deep body, well developed limbs and a dorsal colour pattern of light and dark stripes. In addition, both species are ground dwelling and occur in temperate Australia (Fig. 4).

Between the two species, *L. baudini* appears to be the primitive and *L. entrecasteauxii* the derived form: *L. baudini* has the supranasal and postnasal completely distinct from the nasal whereas *L. entrecasteauxii* has the supranasal and postnasal partially or completely fused to the nasal. *L. baudini* may also be more primitive than *L. entrecasteauxii* in having two anterior loreals instead of one[1] and the prefrontals in broad contact. These features plus the separate frontoparietals and deep head and body mark *L. baudini* as one of the most generally primitive species in the genus *Leiolopisma* (along with *L. spenceri* — see Greer 1974 and 1980).

SPECIMENS EXAMINED: The following specimens of *Leiolopisma entrecasteauxii* from South Australia were examined for the purposes of detailed comparison with *L. baudini:* British Museum (Natural History) 1923 11.11.37 — Pearson Island; South Australian Museum R 5768 — Elliston; R 10209 — Flinders Island; R 11181 — 11182 — South Neptune Island; R 15990 — Reevesby Island; Australian Museum R 74819 — 74832 — Port MacDonnell; R 74872 — 74888 — Beachport.

NOTES ON THE BIOLOGY OF MAINLAND AUSTRALIAN AND TASMANIAN *LEIOLOPISMA*

During the course of field work in southwestern and southeastern Australia in the period 1975-1980, I made observations on all the species of *Leiolopisma* except *L.*

[1]The phylogenetic significance of the two anterior loreals in lygosomines is not clear as yet. The evidence for its being primitive is that it occurs in the moderately primitive representatives of two major groups of lygosomines: the *Eugongylus* group, of which *Leiolopisma* is a member, and the *Sphenomorphus* group (for the diagnosis and contents of these two groups see Greer 1979). The evidence against two anterior loreals being primitive — and hence the evidence for its being derived — is that it does not occur in *Mabuya,* the most generally primitive genus of lygosomines, nor does it occur in scincines, the most primitive subfamily of skinks. Two anterior loreals have been observed in the following species of *Leiolopisma: duperreyi* (A.M. R57916, S.A.M. R6142, 12518, 12771, 12852, 16268c), *entrecasteauxii* (N.M.V. D 50886), *ocellatum* (A.M. R 4154), *otagense* (Hardy 1977), *platynotum* (A.M. R 52755, 65772) and *telfairi* (U.S.N.M. 163179).

palfreymani — a species confined to a virtually inaccessible rock in the Southern Ocean south of Tasmania. In this section I briefly summarize those observations that are either new or bear on the problem of species groups in this fauna.

The observations generally fall into three categories — habitat, female reproduction and colour hues — although additional observations are provided for a few species. The species discussed are arranged alphabetically in two species groups as suggested by Rawlinson (1974b). These species groups are discussed further in the following section.

I should like to point out that some of the topics I discuss below have been treated by Pengilley (1972) in an as yet unpublished Ph.D. thesis. I am informed by the author that the result of this thesis will be published.

The *Baudini* Species Group

Leiolopisma coventryi

As Rawlinson (1975) has provided extensive natural history notes for this southeast Australian species, I will make only a few supplementary observations based on 105 specimens comprising four samples collected by myself and others at three localities: 9.3 km SE of the Nimmitabel Post Office via the Monaro Hwy, N.S.W. (N = 20, 30 November 1975); WNW slope of Mt. Tallarook, Brown Range, Vic. (N = 24, 21 December 1975 and N = 37, 26 December 1976), and 2 km N of Mt. St. Leonard, Vic. (N = 24, 22 December 1975, the type locality). All the individuals I have seen have either been on the ground or on rotting logs on the ground in open forest. Rawlinson (1975) notes that *L. coventryi* ". . . restricted . . . its activity to logs and litter at or close to ground level (within 1-2 m)."

Data on the size, sex, state of maturity and litter sizes for the four samples from the three localities are given in Table 2. Two interesting observations emerge from these data. First, females appear to attain a larger absolute size than males in all three populations[1]. This is a general trend in small Australian skinks (pers. obs.), but its basis (differential growth versus differential mortality) has not been determined as yet for any Australian species.

Second, there is geographic variation in both body size and litter size. Pairwise comparisons (t test) between the three populations with regard to mean SVL of gravid females with countable ovarian eggs or developing young and mean litter size (based on these same females) revealed the following statistically significant differences: for body size, Mt. St. Leonard ($\overline{X}$ = 45.4, SD = 3.31, N = 10) > Mt. Tallarook ($\overline{X}$ = 42.0, SD = 2.77, N = 21 > Nimmitabel ($\overline{X}$ = 40.8, SD = 2.97, N = 10) and for litter size Mt. St. Leonard ($\overline{X}$ = 2.1, SD = 0.88, N = 10) < Nimmitabel ($\overline{X}$ = 2.9, SD = 0.57, N = 10). The most interesting aspect of this variation is the combination of large body size and small litter size in the Mt. St. Leonard population. I have no explanation for this relationship, but I suspect that microclimatic differences are important as the Mt. St. Leonard locality appeared to be wetter and perhaps cooler than the other localities. A similar relationship holds for a population of *L. pretiosum* living in the very cool climate on the summit of Mt. Wellington, Tasmania (see below).

Rawlinson (1975) noted that *L. coventryi* is live-bearing with a litter size of 1-7 ($\overline{X}$ = 3.0, N = 15). In the four samples I collected, the 41 females with countable enlarged

TABLE 2. Comparison of body size (SVL in mm), state of maturity and litter size in four samples of *Leiolopisma coventryi* collected from three localities. Sample sizes in parentheses.

	9.3 km SE of Nimmitabel, N.S.W. 30/11/1975	Mt. Tallarook, Vic. 21/12/1975	Mt. Tallarook, Vic. 26/12/1976	2 km N of Mt.St. Leonard, Vic. 22/12/1975
Size of unsexed specimens	41(1)[1]	—	—	22-26(4)
Size of immature specimens				
♂♂	—	27(1)	26-28 (5)	—
♀♀	27 (1)	27-29 (5)	25-29 (3)	34 (1)
Size of transitional specimens				
♂♂	—	—	—	—
♀♀	—	—	—	33-42 (3)
Size of mature specimens				
♂♂	35-41 (5)	35-40 (11)	36-43 (10)	—
♀♀	37-48 (13)	36-45 (7)	37-47 (19)	39-54 (16)
Size of gravid females				
Range	37-48 (13)	38-45 (5)	37-47 (19)	39-54 (15)
Mean	40.2	41.6	41.7	45.6
SD	2.95	3.21	2.83	3.94
Litter size				
Range	2-4 (10)	2-4 (5)	1-4 (16)	1-3 (100)
Mean	2.9	2.8	2.4	2.1
SD	0.57	0.84	0.72	0.77

1. The gonads and genital ducts of this specimen were undifferentiated.

ovarian eggs or developing young ranged in size from 37 to 54 mm SVL ($\overline{X} = 42.5$) and had 1-4 ovarian eggs or young ($\overline{X} = 2.5$). There was no significant correlation between female size and litter size ($r = 0.16$, NS). It is interesting to note that all but three of the 53 females judged to be mature were gravid. The exceptions were two females from the 1975 Mt. Tallarook population (SVLs = 36 and 40 mm) and one from the Mt. St. Leonard population (SVL = 46 mm).

Finally, it may be noted that there was no indication of ventral colour in any of the specimens in the four samples discussed above. Rawlinson (1975) also makes no mention of ventral colour in the specimens he examined.

1. I did not obtain any males when I collected at the Mt. St. Leonard locality, but Rawlinson (1975) gives data showing that the largest female in the type series had a SVL of 51.0 mm (N = 28), whereas the largest male had a SVL of only 43.5 mm (N = 8).

Leiolopisma duperreyi

Leiolopisma trilineatum is currently treated as a single species with two disjunct populations, one in the southwestern corner of Australia and the other in the southeastern (Fig. 9 in Greer 1980). The two populations differ, however, in two characters, and these differences suggest to me that two species are involved. The southwestern population, to which the name *L. trilineatum* may be restricted, has a subdued or diffuse dorsal colour pattern and a lower number of paravertebral scale rows and the southeastern population, for which the name *L. duperreyi* is available, has a distinct colour pattern and a higher number of paravertebral scales (Table 3).

TABLE 3. Comparison between *Leiolopisma duperreyi* and *L. trilineatum* in the number of paravertebral scale rows. Note that there is a sexual dimorphism within each species and a difference between the two species within each sex.

		♂♂		♀♀
L. duperreyi	Range:	57-62		62-66
	$\bar{X}$:	59.6	t = 9.87***	64.1
	SD:	1.50		1.33
	N:	18		20
		t = 6.65***		t = 8.26***
L. trilineatum	Range:	54-59		56-61
	$\bar{X}$:	56.3	t = 6.65***	59.8
	SD:	1.55		1.97
	N:	20		25

I have seen only 11 *L. duperreyi* in the field and all were on the ground in open habitats such as woodlands, shrublands or heathlands. Rawlinson (1974a) notes that in Tasmania *L. duperreyi* is restricted to open areas which contain low tussock grasses and heaths and that it may ascend these plants to bask.

Rawlinson (1974a) reported that the species is oviparous and that in Tasmanian specimens clutch size was 4-8 ($\bar{X}$ = 5.5, N = 11). In order to extend these observations, I examined the collections in the Australian Museum and the South Australian Museum for gravid females. I found one female with enlarged ovarian eggs that was collected on 17 November and eleven females with oviducal eggs that were collected in the period 3 November–"February" in different years. The gravid females ranged in size from 54 to 71 mm SVL ($\bar{X}$ = 60.1) and contained 3-7 eggs ($\bar{X}$ = 4.8). There was no significant correlation between female size and clutch size (r = 0.42, NS).

Rounsevell (1978) reported that all the specimens in a large series of hatchlings from a single commual nest (N = 63) had a "bright orange throat-patch". I have also noted a rosy-orange throat colour in larger specimens.

Leiolopisma entrecasteauxii

This species is restricted to southeastern Australia and Tasmania (Fig. 4). I have seen several hundred individuals and in my experience the species is largely ground-dwelling, although it often ascends low rocks and logs in order to bask (also see Rawlinson 1974a).

The species is live-bearing (Harrison and Weekes 1925 and Weekes 1930) with a reported litter size in Tasmanian animals of 1-7 ($\bar{X}$ = 4.1, N = 56, Rawlinson 1974a). I have examined the Australian Museum and South Australian Museum collections for gravid females and have found 45 females from throughout the range with either yolking ovarian eggs or oviducal young. These females ranged in size from 45 to 65 mm SVL ($\bar{X}$ = 54.2) and had litters of 1 to 7 ($\bar{X}$ = 4.4). There was a significant, positive correlation between female size and litter size (r = 0.61***).

Two colour patterns occur in what is now considered a single species: one with distinct light longitudinal stripes (Fig. 5) and the other with only indistinct stripes or none at all (Fig. 6). In some areas only one colour pattern occurs. All the South Australian and far western Victorian populations, for example, appear to lack stripes whereas all the Tasmanian and New England Tableland populations appear to have them (pers. obs.). In the striped populations, mature males usually have red in the anterior part of the lower light lateral stripe and no bright ventral hues. In some faintly striped or unstriped populations, however, males "develop an irregular red mid-lateral stripe during late summer and autumn only. Often this red colouring is limited to the axillary region. At the same time, the underside of the body and tail becomes bright pink to red, but the chin and throat, as far as I have seen (approx. 50-60 specimens, from at least 6 populations) always remain white" (Mr Mark Hutchinson, pers. comm. in letter of 3 December 1979, describing his experience in Victoria). In contrast to the lack of throat colour and the presence of ventral body colour in these animals, I can note having seen two faintly striped animals from the highlands of southeastern New South Wales (collected by Mr Graham Hardy) which had a distinct reddish wash on the throat but clear venters. It is not clear whether these two pattern types — striped vs faintly striped or unstriped — represent distinct species or simply morphs of one species. The two forms are very similar in morphometric characters, hence future taxonomic work may be most profitable if it focuses on biochemical characters and field biology.

Leiolopisma metallicum

I collected 168 specimens of this species from 13 localities in Tasmania in the period 4-15 December 1975. My observations for these specimens support Rawlinson's (1974a) observation that "fallen logs, the trunks and lower limbs of trees and rock surfaces are all used for basking sites during activity, but most of the time is spent at or close to ground level". I found this species and *L. pretiosum* together in large numbers at two localities and at both I noticed that *L. metallicum* was usually on the ground while *L. pretiosum* was usually on logs.

The state of sexual maturity and size of the specimens I collected are given in Table 4. The most interesting observation to be made on these specimens is that every mature female (N = 83) except one was gravid with early term oviducal young. This indicates that almost all mature females mate and reproduce and that there is a notable degree of synchrony in reproduction. The one non-gravid female was a relatively small specimen (SVL = 48 mm).

L. metallicum is a live-bearing species (Weekes 1930) with a reported litter size of 1-7 ($\bar{X}$ = 3.9, N = 44; Rawlinson 1975). In my specimens there was a significant positive correlation (r = 0.81***, N = 75) between female SVL ($\bar{X}$ = 53.4, range = 42-66 mm) and brood size ($\bar{X}$ = 3.9, range = 2-8).

Fig. 5. The strongly patterned form of *Leiolopisma entrecasteauxii*. The specimen is from approximately 4 km SSW of Woodside East, Vic.

Fig. 6. The weakly patterned form of *Leiolopisma entrecasteauxii*. The specimen is from Shooters Hill, Oberon, N.S.W.

Many but not all of the specimens in my collection had a metallic rose colour on the venter from the level of the forelegs posteriorly onto the base of the tail. The colour occurred in specimens of all sizes in both sexes.

TABLE 4. Data on state of sexual maturity and body size in 168 specimens of *Leiolopisma metallicum* collected in Tasmania in the period 4-15 December 1975. Sample sizes are given in parenthesis.

Maturity	SVL (mm)
Immature	
♂♂	29-34 (12)
♀♀	28-40 (8)
Transitional	
♂♂	37 (1)
♀♀	42-44 (2)
Mature	
♂♂	41-60 (62)
♀♀	42-66 (83)

Leiolopisma platynotum

I have seen only eight individuals of this southeastern Australian (Fig. 9 in Greer 1980) species in the field, and all were on the ground in open woodland or heathland. In addition S. J. Copland (field register on file in the Department of Reptiles and Amphibians in the Australian Museum) noted the position of 15 specimens collected by him and all were on the ground. It would appear therefore that the species is predominantly ground dwelling.

I have found five gravid females in the collections of the Australian Museum. All held shelled oviducal eggs which indicates that the species is oviparous. Three of the females were collected between 15 November and 10 December in different years; another was collected in "November" and another in "January". The females ranged in size from 65 to 80 mm SVL ($\bar{X} = 71.6$) and contained 3-9 eggs ($\bar{X} = 5.4$). There was a significant positive correlation between female size and clutch size ($r = 0.98^{**}$).

My observations plus Copland's indicate that reddish-orange throat colour occurs in most individuals regardless of sex or state of maturity but that the colour is probably most extensive and intense in mature males. The species is commonly known as the "Red-throated Skink".

Leiolopisma trilineatum

I collected 40 specimens of this southwestern Australian species (Fig. 9 in Greer 1980) from seven localities in the period 19-28 October 1976. All specimens were found on the ground, generally under cover. Rubbish tips sited on sandy soils in heathland or sclerophyll shrubland were especially productive.

The animals in my collection were readily separable into two geographic groups on the basis of size: one from around Esperance (two localities) which comprised generally larger animals and the other from the Albany–Augusta area (five localities) which comprised generally smaller animals (Table 5). All but one of the 12 females judged to be mature were gravid. The exception, the largest specimen in the collection (SVL = 72 mm), had enlarged oviducts that appeared to be in preovulatory condition but small ovaries that contained only small, unyolked follicles.

TABLE 5. Data on state of sexual maturity and body size in 40 specimens of *Leiolopisma trilineatum* from two different areas in southwestern Australia collected in the period 19-28 October 1976. Sample sizes are given in parentheses.

Maturity	SVL (mm)	
	Vicinity of Esperance	Albany — Augusta area
Immature		
♂♂	49-52 (3)	37-42 (3)
♀♀	38 (1)	39-42 (3)
Transitional		
♂♂	51 (1)	—
♀♀	52-55 (3)	43 (1)
Mature		
♂♂	51-66 (6)	44-62 (7)
♀♀	60-72 (5)	54-65 (7)

The collections of the Australian Museum and the Western Australian Museum were examined for gravid females. Five were found with enlarged ovarian eggs. These females were collected in the period 19-24 October (N = 4) and 5 February (N = 1) in different years. An additional thirteen females were found with shelled oviducal eggs indicating that the species is oviparous. These females were collected in the period 19 October–9 February in different years. The 18 gravid females ranged from 51 to 66 mm SVL ($\overline{X}$ = 59.6) and contained 3-6 eggs ($\overline{X}$ = 4.5). There was a significant positive correlation between female size and clutch size (r = 0.58*).

The only ventral colouration I have noted in this species is a pink to deep salmon reddish wash on the chin and throat (Fig. 4 in Greer 1980). The between-population variability of this colour suggests that it may be seasonally and/or geographically variable. In the vicinity of Esperance, for example, the earliest visited (19-21 October) and easternmost locality, none of the specimens (N = 19) showed any sign of throat colour. At Albany, however, a few days later (24 October) and further west, some but not all (N = 9) showed throat colour, and at Augusta, a few days later again (27-28 October) and still further west, all the specimens (N = 9) had throat colour.

The *Spenceri* Species Group

Leiolopisma greeni

In describing this endemic Tasmanian species Rawlinson (1975) discussed many aspects of its natural history, and the following observations are made to complement and extend Rawlinson's account. I collected 51 specimens from two nearby localities on the northern edge of the Central Pleateau in 1975: the vicinity of Mickey's Creek, 2.2 km N of Breona by road (N = 1, 5 December, approx. 1180 m) and along Halfmoon Creek from its exit from Pine Lake to a point about 500 m downstream (N = 50, 13 December, approx. 1150m). All specimens seen were on the grey doleritic rocks that form the edge of the creeks and often cover them in bare "rock fields". Most of the animals were in the vicinity of the creeks but in the rock fields a few were 50-100 m away from where the creek would be heard flowing under the rocks. When alarmed, most animals fled into crevices between the boulders, but a few jumped into the creek.

Along Halfmoon Creek the animals were relatively common and we often saw 3 to 6 individuals of various sizes in close proximity. We did not observe any aggressive intraspecific interactions, but we did note a young adult *L. greeni* give way to a larger *L. ocellatum,* the only specimen of this species that we saw at this locality.

Most of the specimens we saw were sedentary, generally basking, but on occasion they would dash out to chase a passing insect. We observed one young adult, however, foraging downstream along the edge of Halfmoon Creek for 25 m or so, occasionally entering the water to get from one rock to another.

I took the body and associated air temperatures (1 cm above the lizard's location) with a Schultheis Thermometer of 16 relatively large and undisturbed basking individuals along Halfmoon Creek in the period 13:30-17:30 hrs. At the beginning of this period there were only a few clouds but these increased gradually and by the end of the period it was nearly completely overcast. A few animals were still to be seen out on the warm, west facing rock surfaces at the end of the time, however. The body temperatures of the animals ranged from 24.3–32.3°C ($\bar{X}$ = 27.4, SD = 2.50) and air temperatures ranged from 15.1–22.4°C ($\bar{X}$ = 18.3, SD = 2.27). The greatest difference between body and air temperature was 14.0°C. Rawlinson (1975) reported a mean preferred temperature for the species of 28.9°C.

Rawlinson (1975) noted that the species is live-bearing with a litter size of 3 (N = 3) and birth in early March. In my collection immature males ranged from 30 to 53 mm SVL ($\bar{X}$ = 39.5, SD = 7.39, N = 14) and immature females 39 to 55 ($\bar{X}$ = 46.3, SD = 6.06, N = 6); mature males ranged from 55 to 67 mm ($\bar{X}$ = 62.5, SD = 3.70, N = 15) and mature females 54 to 72 mm($\bar{X}$ = 63.1, SD = 4.88, N = 15). Half (N = 8) the mature females were gravid. All had early term oviducal young and those with countable litters ranged in size from 62 to 68 mm SVL ($\bar{X}$ = 64.7, N = 4) and had 2-3 ($\bar{X}$ = 2.3, N = 4) young. The remaining mature females (N = 8), which did not differ from the gravid females in size (SVL = 60-72 mm, $\bar{X}$ = 63.6, SD = 4.87 vs 54-70 mm, $\bar{X}$ = 63.0, SD = 4.99), had neither corpora lutea nor developing follicles. However, these females did have large collapsed oviducts and were probably the mothers of what appeared to be the youngest age class (SVLs = 30-33 mm, $\bar{X}$ = 31.4, SD = 1.52, N = 5). These observations suggest that the females may reproduce biennially. Biennial reproduction would not be surprising in *L. greeni* as it is the "only species of reptile in Australia which is restricted to alpine areas" (Rawlinson 1975), and biennial

reproduction is well known in other reptiles inhabiting areas with short, cool growing seasons (Fitch 1970).

None of my specimens showed any trace of ventral colour, but a greenish or coppery irridescence in the dorsal colour was evident in certain light.

Leiolopisma ocellatum

I collected 32 specimens of this endemic Tasmanian species from nine localities in the period 4-15 December 1975. All specimens were collected in open habitats with low rocky outcrops and most were found on rocks.

The species is viviparous (Weekes 1930) with a reported litter size of 4 (N = 2; Rawlinson 1975). The size classes of the three categories of sexual maturity in my collection are given in Table 6. All females judged to be mature (N = 13) were gravid with early stage young. The nine females with countable litters plus two gravid females in the collections in the Australian Museum (both collected 14 January 1978) ranged in size from 58 to 71 mm ($\overline{X}$ = 64.4) SVL and had litters of 2-4 ($\overline{X}$ = 2.6). There was a significant positive correlation between female size and litter size (R = 0.83**).

None of the living specimens I have seen had any trace of ventral colour.

Leiolopisma pretiosum

I collected 54 specimens of this endemic Tasmanian species at four widely scattered localities in the period 7-15 December 1975: 8.7 km S of Buckland (9 December; approx. 320 m; N = 3); 26.8 km S of Wilmot Post Office (15 December; approx. 780 m; N = 11); 17.4 km N of Breona (4 December; approx. 990 m; N = 18), and the summit of Mt. Wellington (7-8 December; 1270 m; N = 32).

The Mt. Wellington locality is the highest and most southern of the four and the animals from there differ from those at the other three localities in several interesting ways. First, the Mt. Wellington animals attain a larger body size than the others (see all four measures of body size assessed in Table 7). They do not show, however, a significant concomitant increase in litter size ($\overline{X}$ = 2.40, SD = 1.01, N = 9 vs $\overline{X}$ = 2.00, SD = 0.50, N = 9; t = 1.06; NS). Second, the Mt. Wellington animals have more numerous and smaller body scales than the others. The regression line for mid-dorsal scale size vs snout-vent length has a slope of 0.036 and an intercept of -0.007 for the Mt. Wellington animals (F = 103.37***) and a slope of 0.052 and an intercept of -0.294 for the other animals (F = 92.04***). The slopes of these two lines are significantly different (F = 7.07***). Lizards from cooler climates generally have smaller body scales than their relatives from warmer climates (Regal 1975), and this relationship seems to apply in these populations. Third, none of the Mt. Wellington animals showed any colour hues, whereas many but not all of the sexually mature animals from the other localities had a pink wash on the venter over the posterior part of the body and the base of the tail.

I took cloacal temperatures on most of the Mt. Wellington animals, and these are of interest due to the relatively cool ambient temperatures to which the lizards were exposed. The summit of Mt Wellington is an open habitat consisting of low open heath and rock outcrops. At the time the specimens were collected and their temperatures recorded (8 December; 14:00-16:00 hrs) the weather was mostly clear but very windy and cool and the animals observed were basking — primarily on the base of the rocks. I took the body temperatures (with a Schultheis Thermometer) of 30

TABLE 6. Data on state of sexual maturity and body size in 32 specimens of *Leiolopisma ocellatum* collected in Tasmania in the period 4-15 December 1975. Sample sizes are given in parentheses.

Maturity	SVL (mm)
Immature	
♂♂	34-37 (3)
♀♀	38 (2)
Transitional	
♂♂	50-54 (2)
♀♀	49-56 (3)
Mature	
♂♂	54-74 (9)
♀♀	58-71 (13)

TABLE 7. Data on body size (SVL in mm), state of maturity, litter size and number of scale rows at midbody in four samples of *Leiolopisma pretiosum* from four localities. Sample sizes are given in parentheses.

Character	8.7 km S of Buckland (320 m)	26.8 km S of Wilmot (780 m)	17.4 km N of Breona (990 m)	Summit of Mt. Wellington (1270 m)
Size of unsexed specimens	—	—	—	24 (1)
Size of immature specimens				
♂♂	—	31 (1)	34-35 (3)	44-49 (2)
♀♀	—	—	32 (1)	42-49 (5)
Size of mature specimens				
♂♂	48-49 (2)	44-50 (5)	44-51 (9)	55-62 (13)
♀♀	44 (1)	45-50 (5)	46-50 (6)	51-63 (10)[1]
Size of gravid females				
Range	44 (1)	45-50	46-50	51-63
Mean	—	48.0 (5)	47.4 (5)	57.1 (9)
Litter size				
Range	?	2-3	1-2	2-4
Mean	?	2.2 (5)	1.8 (4)	2.4 (9)
Number of longitudinal scale rows at midbody				
Range	32-34	32-36	33-36	36-42
Mean	32.7 (3)	33.9 (11)	34.5 (18)	39.1 (32)
SD	—	1.22	1.02	1.58

1. Does not include one badly mangled gravid female.

individuals which were both relatively large and undisturbed. I also took the air temperatures 1 cm above the basking site (always a rock) for each lizard. Body temperatures ranged from 22.6–31.8°C ($\overline{X}$ = 27.3, SD = 2.06) and air temperatures 13.2–19.9°C ($\overline{X}$ = 17.6, SD = 1.59). The greatest difference between a body temperature and the air temperature was 18.6°C. Rawlinson (1974) states that the voluntary minimum activity temperature for the species is 21.5°C, the voluntary maximum activity temperature 37.2°C and the mean 29.1°C.

L. pretiosum is a live-bearing skink (Lucas and Frost 1894 and Weekes 1930) with a reported litter size of 2-4 ($\overline{X}$ = 2.9, N = 8; Rawlinson 1974a). The young are stated to be born in February (Rawlinson 1974a). In my collection all but one of the females judged to be mature (N = 22) were gravid. The exception was a specimen of 49 mm SVL from 17.4 km N of Breona. This animal had well-developed oviducts but only unyolked follicles and no corpora lutea. In the 19 gravid females with countable ovarian eggs or oviducal young that I have examined (14 specimens collected personally plus two already in the collections in the Australian Museum), there was a significant (r = 0.51*) positive correlation between female SVL ($\overline{X}$ = 52.2, range = 45-63 mm) and brood size ($\overline{X}$ = 2.2, range = 1-4).

Leiolopisma spenceri

As Rawlinson (1974b) has given detailed natural history notes for this southeast Australian endemic, I will make only a few supplementary observations based largely on preserved specimens.

Rawlinson (1974b) reports that the species is ". . . restricted to dead trees or rocky outcrops in montane wet sclerophyll forests and rocky outcrops in subalpine woodlands. The exposed surfaces of the trees or rocks are used for basking and foraging sites during activity, while crevices are used for shelters when inactive". My own much more limited experience supports these observations.

Rawlinson (1974b) reported litter sizes of 1-3 ($\overline{X}$ = 1.9, N = 29). I surveyed all the specimens in the Australian Museum and the Museum of Comparative Zoology for gravid females and found 13, all with developing young in the oviducts. The available dates of collection (N = 11) were between 30 November and 8 March in various years. The 13 females ranged in size from 52 to 63 mm SVL ($\overline{X}$ = 57.2) and carried 1-4 young ($\overline{X}$ = 2.5). There was a significant positive correlation between female size and litter size (r = 0.70**).

I have examined closely only 11 live specimens, but none had any ventral colour. Rawlinson (1974b) also makes no mention of ventral colour.

SPECIES GROUPS IN MAINLAND AUSTRALIA AND TASMANIAN *LEIOLOPISMA*

Rawlinson (1974b and 1975) has suggested that the Australian and New Zealand skinks now placed in the genus *Leiolopisma (sensu* Greer 1974) can be divided into two groups on the basis of the number of midbody scale rows: one group with 20-32 scale rows and the other with 38-66 scale rows. I believe Rawlinson's suggestion has merit at least for the mainland Australian and Tasmanian species and below I offer some additional characters for the two groups in this area.

The group with a low number of midbody scale rows, or to put the character in a more biologically meaningful way, the group with relatively large scales covering the body, shows the following suite of characters: 24-32 longitudinal scale rows at

TABLE 8. Comparison of certain morphometric and reproductive parameters in the two species groups in mainland Australian and Tasmanian *Leiolopisma*. Sample sizes are given in parenthesis.

	Midbody scale rows	Prefrontals meet (expressed as a frequency)	Hind limb length/snout-vent length	Tail length/ snout-vent length	Mode of reproduction	SVL of gravid ♀♀ (mm)	Brood size
baudini species group							
baudini	26 (1)	1.00 (1)	0.33 (1)	?	?	—	—
coventryi	25-29 (133)	0.00 (48)	0.31-0.39 (72)	1.10-1.51 (33)	viviparous	37-54 (41) X̄ = 42.5	1-4 (41) X̄ = 2.5
entrecasteauxii	25-33 (47)	0.11 (114)	0.29-0.42 (47)	1.23-1.65 (54)	viviparous	45-65 (45) X̄ = 54.2	1-7 (45) X̄ = 4.4
duperreyi	26-30 (30)	0.02 (46)	0.27-0.33 (39)	1.16-1.75 (10)	oviparous	54-71 (12) X̄ = 60.1	3-7 (12) X̄ = 4.8
metallicum	24-28 (24)	0.00 (141)	0.25-0.38 (22)	1.25-1.73 (12)	viviparous	42-66 (75) X̄ = 53.4	2-8 (75) X̄ = 3.9
platynotum	24-32 (30)	0.06 (31)	0.27-0.42 (41)	1.32-1.85 (18)	oviparous	65-80 (5) X̄ = 71.6	3-9 (5) X̄ = 5.4
trilineatum	26-30 (32)	0.11 (18)	0.28-0.36 (18)	1.57-1.76 (5)	oviparous	51-66 (18) X̄ = 59.6	3-6 (18) X̄ = 4.5
spenceri species group							
greeni	40-44 (16)	0.06 (51)	0.37-0.47 (25)	1.24-1.41 (17)	viviparous	62-68 (4) X̄ = 64.8	2-3 (4) X̄ = 2.3
ocellatum	45-58 (*)	0.09 (32)	0.33-0.43 (22)	1.26-1.38 (8)	viviparous	58-71 (11) X̄ = 64.4	2-4 (11) X̄ = 2.6
palfreymani	38-40 (4)	0.00 (3)	?	?	?	—	—
pretiosum	32-42 (64)	0.25 (32)	0.37-0.43 (17)	1.14-1.58 (9)	viviparous	45-63 (19) X̄ = 52.5	1-4 (19) X̄ = 2.2
spenceri	37-48 (98)	0.16 (67)	0.37-0.44 (21)	1.26-1.45 (28)	viviparous	52-63 (13) X̄ = 57.2	1-4 (13) X̄ = 2.5

* Data from Rawlinson 1975; sample size not given.

midbody; colour hues generally present in at least one sex during at least some time of year (but lacking in *L. coventryi*); relatively short limbs; largely ground-dwelling habits; a relatively large brood size (Table 8 and Fig. 7), and a significant positive interspecific correlation between mean snout-vent length of gravid females and mean brood size ($r = 0.96^{**}$). This group, for which I suggest the name "*L. baudini* group" after its most primitive member (see above), comprises the following species: *baudini, coventryi, entrecasteauxii, duperreyi, metallicum, platynotum* and *trilineatum*.

The group with relatively small scales shows the following characters: 32-58 scale rows at midbody; colour hues generally lacking (but present in some *L. pretiosum*); relatively long limbs; largely saxicolous or arboreal habits; a relatively small brood size (Table 8 and Fig. 7), and no significant interspecific correlation between mean snout-vent length of gravid females and mean brood size ($r = 0.50$, NS). This group, the "*L. spenceri* group" after its most primitive representative (Greer 1974 and 1980), comprises: *greeni, ocellatum, palfreymani, pretiosum* and *spenceri*. The two groups also appear to differ somewhat in ecology, if general distribution is any indication. For

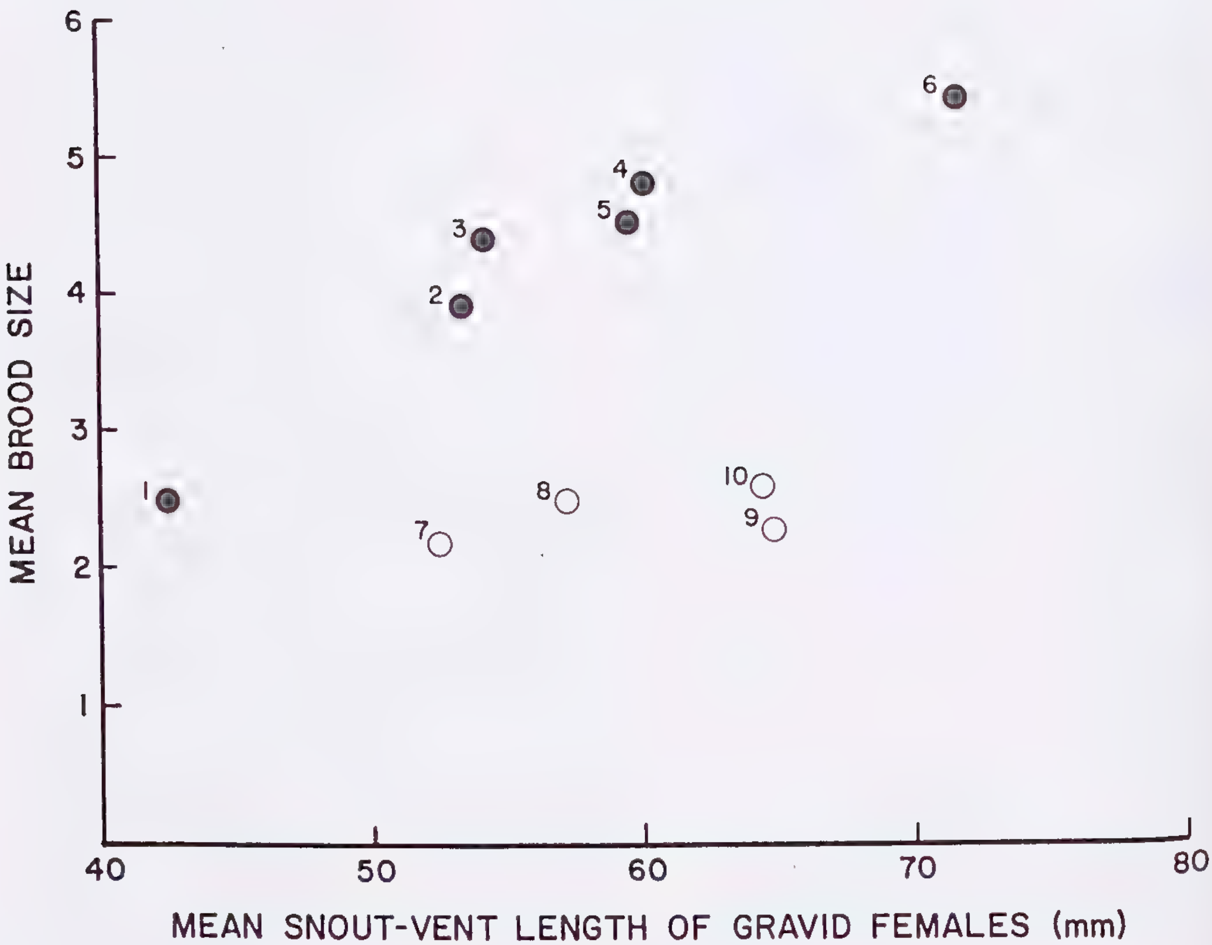

Fig. 7. Relationship between mean size (SVL) of gravid females and mean brood size for the mainland Australian and Tasmanian species of *Leiolopisma*. Black dots represent species in the *L. baudini* group (1 — *coventryi*, 2 — *metallicum*, 3 — *entrecasteauxii*, 4 — *duperreyi*, 5 — *trilineatum* and 6 — *platynotum*) and open circles represent species in the *L. spenceri* group (7 — *pretiosum*, 8 — *spenceri*, 9 — *greeni* and 10 — *ocellatum*).

example, the *L. baudini* group extends into warmer and drier habitats than the *L. spenceri* group.

Rawlinson (1974b) thought that the dichotomy in the Australian *Leiolopisma* species could be extended to the New Zealand species, but the scale counts in Hardy (1977) do not bear this out. Further comparisons between the Australian and New Zealand species would be interesting, but they are prohibited at present by a general lack of information on some of the relevant morphometric and ecological parameters in the New Zealand species, e.g. habitat, limb length, brood size relative to female size and ventral coloration.

A KEY TO THE SPECIES OF *LEIOLOPISMA* IN MAINLAND AUSTRALIA AND TASMANIA

1. Supranasals present 2

   Supranasal absent 4

2. Frontoparietals distinct 3

   Frontoparietals fused .... *palfreymani*

3. Midbody scale rows 26 .... *baudini*

   Midbody scale rows 37-38 .... *spenceri*

4. Frontoparietals paired 5

   Frontoparietals fused 6

5. Size large (maximum SVL = 65 mm); supraciliaries usually 5; dorsal scales often weakly striate; colour pattern usually featuring longitudinal light stripes, albeit diffusely in some populations .... *entrecasteauxii*

   Size small (maximum SVL = 57 mm);supraciliaries usually 6; dorsal scales smooth; colour pattern without longitudinal light stripes .... *coventryi*

6. Midbody scale rows 24-32; if scale rows 32, supraciliaries usually 5 7

   Midbody scale rows 32-58; if scale rows 32, supraciliaries usually 6 or 7 10

7. Supraciliaries usually 6 or more; ventral colour if present a metallic rose on body; viviparous .... *metallicum*

   Supraciliaries usually 5; ventral colour if present a salmon pink to red on throat; oviparous 8

8. Size larger, up to 80 mm SVL; dorsum uniform in colour without pattern; sides with a distinct dark brown band; no longitudinal light stripes ...*platynotum*

   Size smaller, not exceeding 72 mm SVL; dorsum often with narrow dark longitudinal stripes; sides with a more diffuse brown band; longitudinal stripes usually evident albeit faintly 9

9. Longitudinal light stripes usually diffuse; paravertebrals in males 54-59, in females 56-61; southwestern Australia .... *trilineatum*

   Longitudinal light stripes usually distinct; paravertebrals in males 57-62, in females 62-66; southeastern Australia .... *duperreyi*

10. Colour pattern of sides no different from dorsum — uniform dark brown to almost black with uniform, pale yellow flecking .... *greeni*

    Colour pattern of sides different from dorsum — sides darker brown 11

11. Midbody scale rows 32-42 .... *pretiosum*

    Midbody scale rows 45-58 .... *ocellatum*

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ADDENDUM

During the inordinately long period this paper was in press (30 months), *Leiolopisma zia* was described by Ingram and Ehmann (1981). This species is from the closed forests of southeastern Queensland and northeastern New South Wales and is a member of the *baudini* species group. It would key to *L. coventryi* in the key above but can be distinguished from this species on the basis of fewer subdigital lamellae (14–17 vs 19–23) and bright yellow colour from chest to vent (vs light grey).

Reference

Ingram, G. and H. Ehmann, 1981. A new species of scincid lizard of the genus *Leiolopisma* (Scincidae: Lygosominae) from southeastern Queensland and northeastern New South Wales. *Mem. Qld. Mus.* 20: 307–310.

REVIEW OF THE INDO-PACIFIC PIPEFISH GENUS *STIGMATOPORA* (SYNGNATHIDAE)

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SUMMARY

The syngnathine (tail-pouch) genus *Stigmatopora* (type-species: *Syngnathus argus* Richardson) is rediagnosed and compared to other pipefishes with confluent superior trunk and tail ridges. Descriptions, illustrations, key, synonymies and data on variation and distribution are given for the three recognized species: *S. argus* (Australia), *S. nigra* (Australia and New Zealand), *S. macropterygia* (New Zealand and Auckland Is.).

INTRODUCTION

In continuation of review studies of Indo-Pacific pipefishes, I here treat the syngnathine (tail-pouch) genus *Stigmatopora* Kaup. References to species of the genus are not uncommon in regional literature but most consist of inadequate descriptions, inclusion in keys and species lists or more detailed treatments of a few specimens from restricted localities. As a result, the nomenclature is in part confused, descriptions and diagnoses are often inadequate, identification is difficult, distribution is uncertain and little information on intraspecific variation is available. This report, based on the majority of known museum holdings, clarifies some of these problems and provides a basis for future detailed studies on the biology and ecology of these subtropical-temperate pipefishes.

METHODS AND MATERIALS

Distal portions of the tail are often lost in specimens of *Stigmatopora* and frequencies of tail rings are not employed here for species identification. For the same reason, total length (TL) measurements are often of uncertain accuracy and proportional data are here referred to measurements (mm) of head length (HL). Coloration may be sexually dimorphic and may also exhibit considerable individual variation within and between samples of the same species. Present colour descriptions are therefore based on the most characteristic or more frequently encountered markings of specimens preserved in alcohol. Some meristic data (Tables 2-5) have been grouped to simplify presentation and these may not agree exactly with counts given in diagnoses and descriptions. As employed here, the term "venter" refers to the ventral surface. Measurements in Materials Examined sections are approximate and, except in the case of type material, loss of distal tail rings or other damage is not indicated. Lengths of damaged types are approximations of the present overall length. Other methods and definitions of counts and measurements follow Dawson (1977).

Abbreviations for repositories of examined material follow: AMS — Australian Museum, Sydney; BMNH — British Museum (Natural History); GCRL — Gulf Coast Research Laboratory Museum; MCZ — Museum of Comparative Zoology, Harvard Univ., MNHN — Muséum National d'Histoire Naturelle, Paris; NMNZ — National

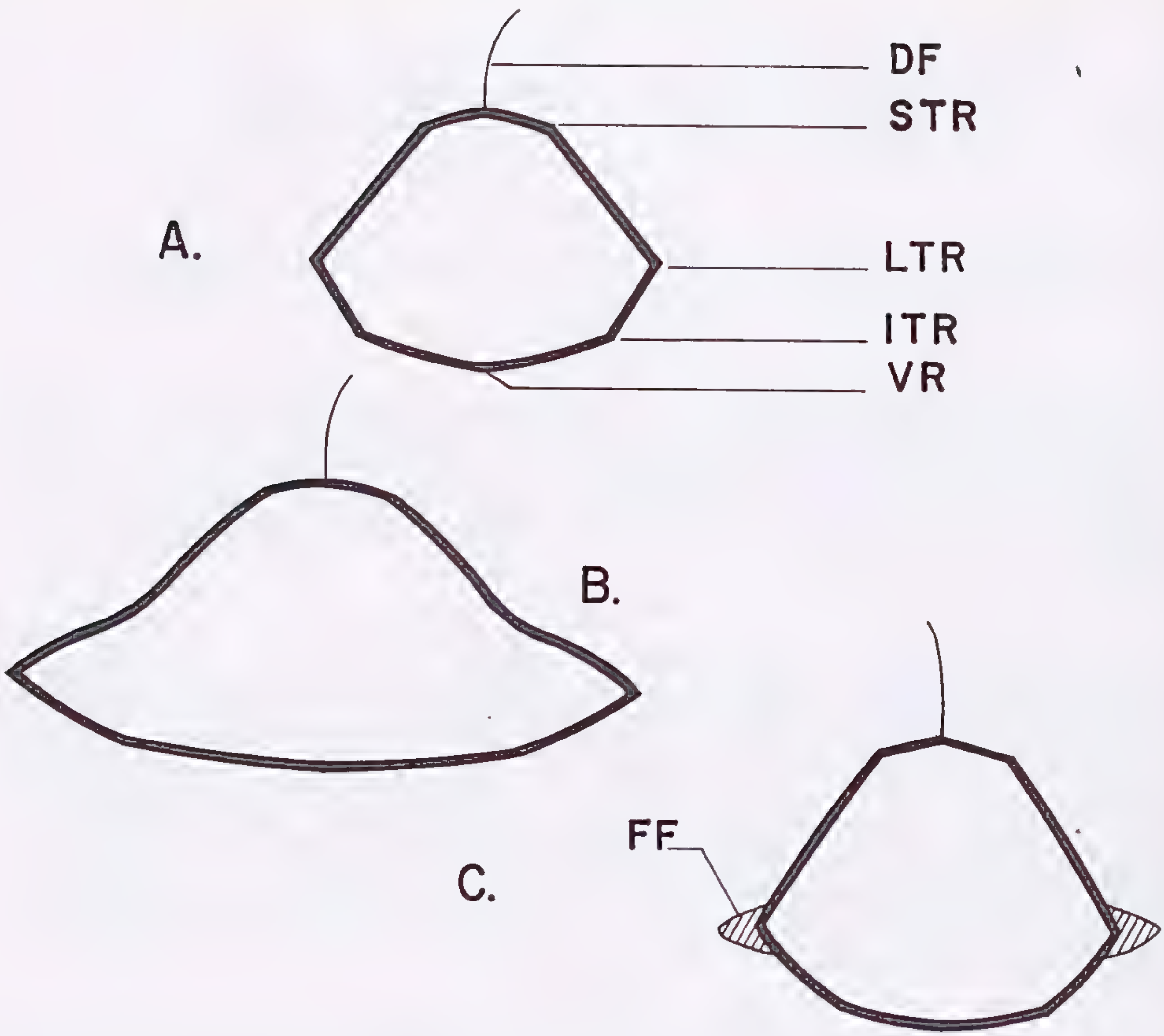

Fig. 1. Semidiagrammatic delineations of body cross-sections at 5th preanal ring in mature females of *Stigmatopora argus* (A), *S. nigra* (B) and *S. macropterygia* (C). DF — dorsal fin, STR — superior trunk ridge, LTR — lateral trunk ridge, ITR — inferior trunk ridge, VR — median ventral ridge, FF — fleshy fold on lateral trunk ridge.

Museum of New Zealand, Wellington; NMV — National Museum of Victoria, Melbourne; QM — Queensland Museum, Brisbane; QVM — Queen Victoria Museum and Art Gallery, Launceston; SAM — South Australian Museum, Adelaide; WAM — Western Australian Museum, Perth.

Stigmatopora Kaup

Stigmatopora Kaup, 1853:233 (type-species: *Syngnathus argus* Richardson, by monotypy).

Stigmatophora. Kaup, 1856:52 (emended spelling).

Stigmataphora. Castelnau, 1872a:201 (misspelling).

Pipettella (not of Haeckel, 1887) Whitley, 1951:62 (as subgenus of *Stigmatopora:* type-species: *Stigmatopora nigra*, by original designation).

Nigracus Whitley, 1953:135 (gen. nov.; replacement name for *Pipettella*, preoccupied).

Stigmatophota. Kähsbauer, 1978:316 (misspelling).

DIAGNOSIS: Superior trunk and tail ridges continuous, not arched dorsad below dorsal-fin base; lateral trunk ridge, with or without a fleshy marginal fold (Fig. 1), ends without deflection between penultimate trunk ring and 35th tail ring; lateral tail ridge absent; inferior trunk and tail ridges continuous, the former largely located on ventral portion of trunk (Fig. 1); dorsum of trunk flat to slightly convex between superior ridges; venter of trunk flat to slightly V-shaped, without a prominent median ridge; trunk dorsoventrally compressed and expanded laterad, strikingly so in some adult females; tail slender, distally attenuated or thread-like but not coiled ventrad in preservative. Snout long and slender; median dorsal snout ridge low, entire, typically fails to reach interorbital, usually ends just before vertical through nares; preorbital moderately broad, the nares well removed from anterior rim of orbit; interorbital broad, flat to slightly concave; posterior supraorbital and median dorsal head ridges low to obsolete; supraopercular ridges absent; opercle with or within a complete or incomplete longitudinal ridge, elsewhere ornamented with fine radiating striae; gill opening located above middle or posterior third of opercle, not above posterodorsal angle; pectoral-fin base protruding a little laterad, with or without a single longitudinal ridge; principal body ridges low, slightly indented between rings, the margins essentially entire; scutella small, poorly defined, oval and without longitudinal keels; head and body without spines, denticulations or dermal flaps. Dorsal-fin origin on trunk, the fin base not distinctly elevated; pectoral fins broadly rounded; anal fin present; caudal fin absent in larvae and adults. Head length ca. 5.9-7.5 in TL, snout length ca. 1.4-1.7 in HL, snout depth ca. 8-32 in snout length, length of dorsal-fin base 0.5-1.0 in HL, trunk rings 16-23, tail rings ca. 67-92, total subdorsal rings ca. 15-26, dorsal-fin rays 36-75, pectoral-fin rays 11-19, anal-fin rays typically 4. Brood pouch under anterior portion of tail; pouch plates absent or vestigial; pouch eggs not in a continuous gelatinous matrix, deposited in membranous compartments lining dorsum of pouch and protected by well-developed pouch folds which meet or nearly meet on ventral midline. Without bony plate-like inclusions in gill membranes (Dawson, 1978) or odontoid processes in jaws (Dawson and Fritzsche, 1975). Maximum length at least 356 mm; three species; marine and estuarine. Endemic to Australia, New Zealand and Auckland Is.

COMPARISONS: Among the 22 nominal genera of pipefishes with confluent superior trunk and tail ridges, only *Stigmatopora, Syngnathoides* Bleeker 1851 and *Runcinatus* Whitley 1929 share the following character combination: confluent inferior ridges, dorsal-fin origin on trunk, absence of caudal fin, presence of pectoral fins in adults and lateral trunk ridge ending without ventral deflection. *Stigmatopora* and *Syngnathoides* are superficially similar in that they share the elongate snout and a dorsoventrally compressed trunk (in adults) but they differ in a number of primary characters. *Stigmatopora* lacks the distally coiled prehensile tail found in preserved representatives of both *Syngnathoides* and *Runcinatus* and further lacks the dermal flaps found in *Syngnathoides* and the spiny or denticulate body of *Runcinatus.* The lateral trunk ridge is essentially straight and the male brood organ is under the tail in *Stigmatopora,* whereas the ridge is angled dorsad and the brood organ is under the trunk in *Syngnathoides.* Eggs are deposited within a well-developed protective pouch under the anterior part of the tail in males of *Stigmatopora,* whereas eggs are deposited in unprotected membranous compartments under the tail in *Runcinatus.*

REMARKS: Most authors have employed Kaup's (1856) unjustified emendation "*Stigmatophora*", but the correct original spelling from Kaup (1853) is *Stigmatopora.* Whitley (1951) proposed the name *Pipettella* for a new subgenus of *Stigmatopora,*

differentiated solely on the basis of the relatively short snout and relatively great sexual dimorphism of the type-species, *S. nigra*. He later (1953) elevated this nominal taxon to generic rank, without pertinent comment, and introduced *Nigracus* as a replacement name for the preoccupied *Pipettella*. Present studies fail to indicate separate treatment for *Stigmatopora nigra*.

The distal termination of the lateral ridge is often obscured by the pouch folds in brooding males (especially in *argus*) and, although otherwise reasonably distinct, this character is best seen in partially dried specimens.

Pouch folds meet on the ventral midline in some brooding males but they fail to meet in others and portions of the developing eggs may be exposed. One species (*argus*) usually has a very thin and narrow, dorsally directed, membrane along the dorsal edge of the free margins of the pouch folds. This evidently led Herald (1959) to conclude that pouch closure was the inverted type in *Stigmatopora*. Examination of a number of brooding males of each species indicates that closure agrees most closely with the semi type of Herald (1959). Brood-pouch eggs are usually deposited in a single layer and well-developed larvae are often found within the pouch of preserved males.

KEY TO THE SPECIES OF *STIGMATOPORA*

1. Dorsal-fin origin on 5th-7th, usually (79%*) on 6th trunk ring; lateral trunk ridge ends on or near anal ring; often with narrow dark bilateral stripes on underside of head .... *nigra*

   Dorsal-fin origin on 9th-13th trunk ring; lateral trunk ridge ends near or beyond vertical from rear of dorsal-fin base; without dark stripes on underside of head 2

2. Total subdorsal rings 14.75-22.75; dorsal-fin rays 37-64; lateral trunk ridge reaches 8th-20th, usually (97%*) 8th-18th, tail ring; dorsum of trunk often with numerous pale or dark spots .... *argus*

   Total subdorsal rings 23.0-26.25; dorsal-fin rays 63-74; lateral trunk ridge reaches 22nd-35th, usually (89%*) 24th-32nd, tail ring; when present, spots on dorsum restricted to bilateral pairs between trunk rings .... *macropterygia*

*Percent of specimens examined.

Stigmatopora argus (Richardson)
Figs. 2-5

Syngnathus argus Richardson, 1840:29 [orig. descr.; ocellated pipefish; "exact habitat" unknown (probably Tasmania)]; Richardson, 1844:183, pl. 7, fig. 2 (descr.); Zietz, 1908:298 (listed, SA).

Stigmatopora argus. Kaup, 1853:233 (n. comb.; New Guinea, Tas.); Bleeker, 1859:15 (compiled); Mellen, 1919:134, fig. (prehensile tail; among *Zostera*); Jordan, 1919:254 (compiled); McCulloch, 1921:37, fig. 96a (in key; common in sea grass; to 7 in.); Waite and Hale, 1912:308, fig. 48 (in key; synon.; descr.; sexually dimorphic coloration; distr.); Lord, 1923:64 (listed, Tas.); Lord and Scott, 1924:40 (spotted pipefish; to 250 mm; common, Tas.); McCulloch, 1929:93 (synon.; distr.); Scott, 1939:139, 142 (in key; Tas.); Whitley, 1948:14 (listed, WA); Whitley, 1951:62 (compared with *S. nigra*); Whitley and Allan, 1958:61, fig. 13 (very common; S Qld. to WA, Tas.); Scott 1960:88 (synon., in part; comparisons; Tas.);

Scott, 1961:61 (in key, Tas.); Scott, 1963:19, fig. 7 (descr.; notes on eggs and brood pouch); Whitley 1964:38 (compiled); Scott, 1970:35 (compared with *"Ichthyocampus" cristatus*); Scott, 1977:123 (note on opercular ridge); Hutchins, 1979:93 (listed, Rottnest I.); Dawson, 1980a:287 (ref.).

Solegnathus argus. Bleeker, 1855:3, 4, 17 (nomen nudum; as sr. synon. of *Syngnathus argus* Richardson; Tas.).

Stigmatophora Argus. Kaup, 1856:53 (emended spelling; descr.; New Guinea, Tas.); Castelnau, 1872:243 (listed, SA); Castelnau, 1873:77 (descr., Vic.); Castelnau, 1879:355 (listed, NSW).

Stigmatophora argus. Steindachner, 1866:52 (Port Jackson); Duméril, 1870:583 (characters; New Guinea, Tas.); Günther, 1870:190 (descr., distr.); Bleeker, 1878:49 (compiled, New Guinea); Castelnau, 1879:362 (compiled; New Guinea); Klunzinger, 1879:326, 420 (synon.; to 12 cm; Port Phillip and Port Darwin); Macleay, 1882:297 (descr.; Port Phillip, Port Jackson); Tenison-Woods, 1882:23 (listed, NSW); Johnston, 1883:134 (common, Tas.); Johnston, 1890:37 (compiled); Lucas, 1890:39 (listed, Vic.); Lucas, 1891:14 (descr. copied); Duncker, 1907:660 (ref.); Duncker, 1909:239 (synon.; descr.; notes on eggs and brood pouch; distr., in part); Duncker, 1912:234 (ref.); McCulloch, 1914:30 (compared with *S. nigra*); Duncker, 1915:103 (synon.; descr.; distr.); Fowler, 1922:444 (notes "Fiji" specimen, probably from Austr.); Weber and de Beaufort, 1922:97 (synon.; descr.; distr.); Fowler, 1928:112 (ref.; diag.; distr., in part); Bertin and Estéve, 1950:50 (as sr. synon. of *S. unicolor*); Kähsbauer, 1950:272 (counts; descr.; distr., in part); Munro, 1958a:90, fig. 622 (descr.; distr.); Munro, 1958b:141 (ref. New Guinea); Fowler, 1959:144 (descr.); Marshall, 1964:120 (in key; distr.); Taylor, 1964:113 (compiled); Munro, 1967:152, 154, fig. 247 (descr., estuarine; New Guinea); Scott et al., 1974:123, fig. (in key; descr.; to 25 cm; all Austr. states); Shiino, 1976:109 (ocellated pipefish); Carcasson, 1977:77 (descr.; estuaries; distr., in part); Chubb et al., 1979:18 (lower Swan-Avon estuary, WA); Glover, 1979:147, 150, fig. 7 (in vegetation; Kangaroo I.); Scott, 1979:115 (data on Tasmanian sp.); Scott, 1980:106 (listed, Tas.).

Stigmatophora olivacea Castelnau, 1872:244 [orig. descr.; St. Vincents Gulf (SA)]; Castelnau, 1873:77 (emended descr.).

Gastrotokeus gracilis Klunzinger, 1872:44 [orig. descr.; Port Phillip (Vic.)]; Lucas, 1890:39 (compiled).

Stigmatophora olivacea. Macleay, 1882:298 (descr. compiled); Ogilby, 1912:36 (notes spec. from SA).

Stigmatophora depressiuscula Macleay, 1882:299 [orig. descr.; King George's Sound (WA)]; Stanbury, 1969:206 (holotype as Macleay Mus. No. F280).

Stigmatophora gracilis Macleay, 1882:299 (orig. descr.; Tas.); Johnston, 1883:134 (compiled); Johnston, 1890:37 (compiled); Whitley, 1955:119 (incorrectly, as jr. synon. of *S. longirostris*).

Stigmatophora argus var. *brevicau data* (sic) Lucas, 1891:14 (orig. descr.; Geelong Inner, Vic.).

Stigmatophora nigra (not of Kaup). Fowler, 1907:426 (misident.; Fiji).

Stigmatophota (sic) *argus*. Kähsbauer, 1978:316 (descr.; type locality incorrect, as Papua.)

DIAGNOSIS: Dorsal-fin origin on 9th-13th trunk ring; lateral trunk ridge reaches 8th-20th tail ring; pectoral-fin rays usually (97%) 14-18; without dark bilateral stripes on underside of head; often with spots or ocelli on dorsum of trunk.

DESCRIPTION: Trunk rings 16-23; tail rings 78-91 (7 counts); dorsal-fin rays 37-64; pectoral-fin rays 13-18; dorsal-fin origin on 9th-13th (usually 10th-12th) trunk ring; subdorsal rings 11.5-6.25 + 7.0-12.25 = 14.75-22.75; lateral trunk ridge reaches 8th-20th ($\bar{x}$ = 12.6) tail ring; see Tables 1-5 for additional counts. Proportional data based on 27 specimens 14.0-39.2 ($\bar{x}$ = 26.7) mm HL follow: snout length in HL 1.4-1.6 (1.5), snout depth in snout length 11.9-31.6 (17.7), length of dorsal-fin base in HL 0.6-1.0 (0.8), anal ring depth in HL 7.5-13.4 (9.5), trunk depth in HL 6.3-12.2 (8.8), pectoral-fin length in HL 7.7-13.4 (10.7), length of pectoral-fin base in pectoral-fin length 0.9-1.6 (1.2).

Opercular ridge straight or angled a little dorsad, complete in young, often incomplete or vestigial in subadults and adults; trunk depth of adults 1.3-1.9 ($\bar{x}$ = 1.6) in trunk breadth, the ratio not strongly sexually dimorphic; adult females occasionally with an expanded fleshy marginal fold on lateral trunk ridge.

COLORATION: Snout, opercles and much of dorsum of head mainly dusky brown, sometimes blotched with pale; dorsum and upper parts of sides of trunk and anterior tail rings tan to brown, with or without narrow dark or pale bars between rings or with dark or pale spots; remainder of dorsum and sides of tail mainly brownish, usually with narrow dark brown edging on principal ridges; venter of head pale to brownish, without narrow dark bilateral stripes on posterior part of snout, suborbitals and opercles; venter of trunk and tail (except pouch folds) pale to tan, plain or with narrow dark bars between rings on trunk and anterior third of tail; pouch folds plain or spotted faintly with pale but most commonly striped (Fig. 4) in mature males; fin-rays narrowly edged with brown.

Preserved coloration is highly variable but two common patterns (spotted and unspotted) occur in subadults and adults of both sexes. Spotted fish are most common in collections, but both forms and a variety of intergrades may occur in a single sample. Spots may be simple or faintly ocellate, they are brown to near black or occasionally pale (Figs. 3-4) and they occur in 2-8 regular or irregular transverse rows. Spots may completely ornament the dorsal surface from the nape to the anterior part of the tail or they may be reduced to a single row on either side of the dorsal-fin base.

COMPARISONS: *Stigmatopora argus* is best distinguished from its sympatric congener, *S. nigra,* by the longer lateral trunk ridge (reaches 8th-20th tail ring versus 1st tail ring in *nigra*), by the more posterior dorsal-fin origin (on 9th-13th trunk ring versus 5th-7th in *nigra*) and by the absence of dark ventral stripes on the head (usually present in *nigra*). Mature females do not develop the exceptionally broad trunk common to mature females of *S. nigra* (Fig. 8), the spotted dorsal surface and striped brood pouch frequently found in *S. argus* do not occur in *S. nigra* and *S. argus* reaches a greater size (ca. 255 mm TL against ca. 162 mm in *nigra*). In addition, average frequencies of dorsal and pectoral-fin rays are higher in *S. argus* (respectively, 48.0 and 15.4 versus 39.0 and 13.0 in *nigra*), subdorsal trunk rings average 8.6 versus 11.9 in *S. nigra* and the brood pouch is longer (14-24 rings versus 12-16 in *nigra*).

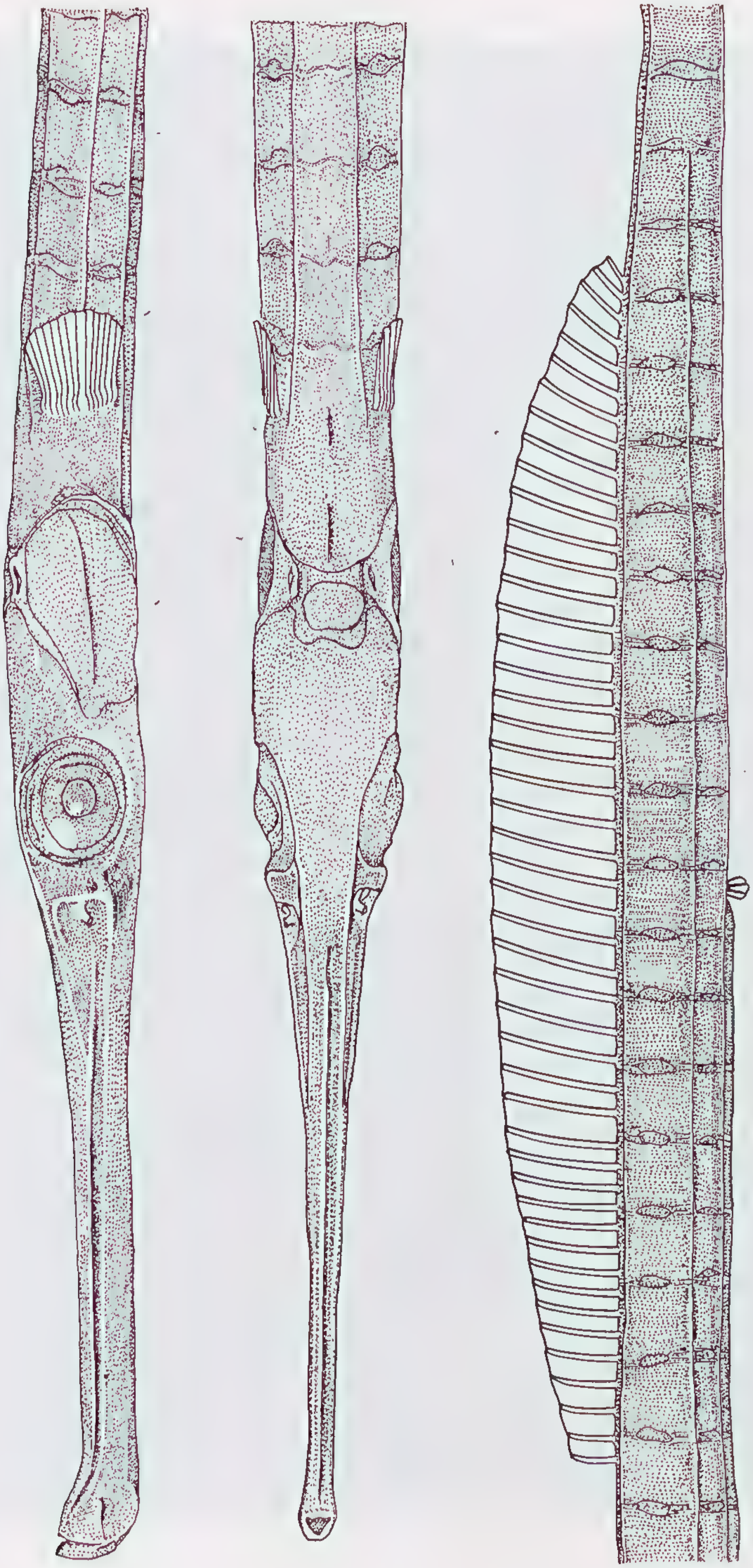

Fig. 2. *Stigmatopora argus*. Lateral and dorsal aspects of head and anterior trunk rings, together with section of body illustrating ridge configuration and dorsal and anal fins. From 114 mm TL adult female (GCRL 16376).

Fig. 3. Stigmatopora argus GCRL 16376 (adult female, ca. 103 mm TL). Top — Lateral aspect, some distal tail rings lost. Bottom — Dorsal aspect of head and anterior portion of trunk.

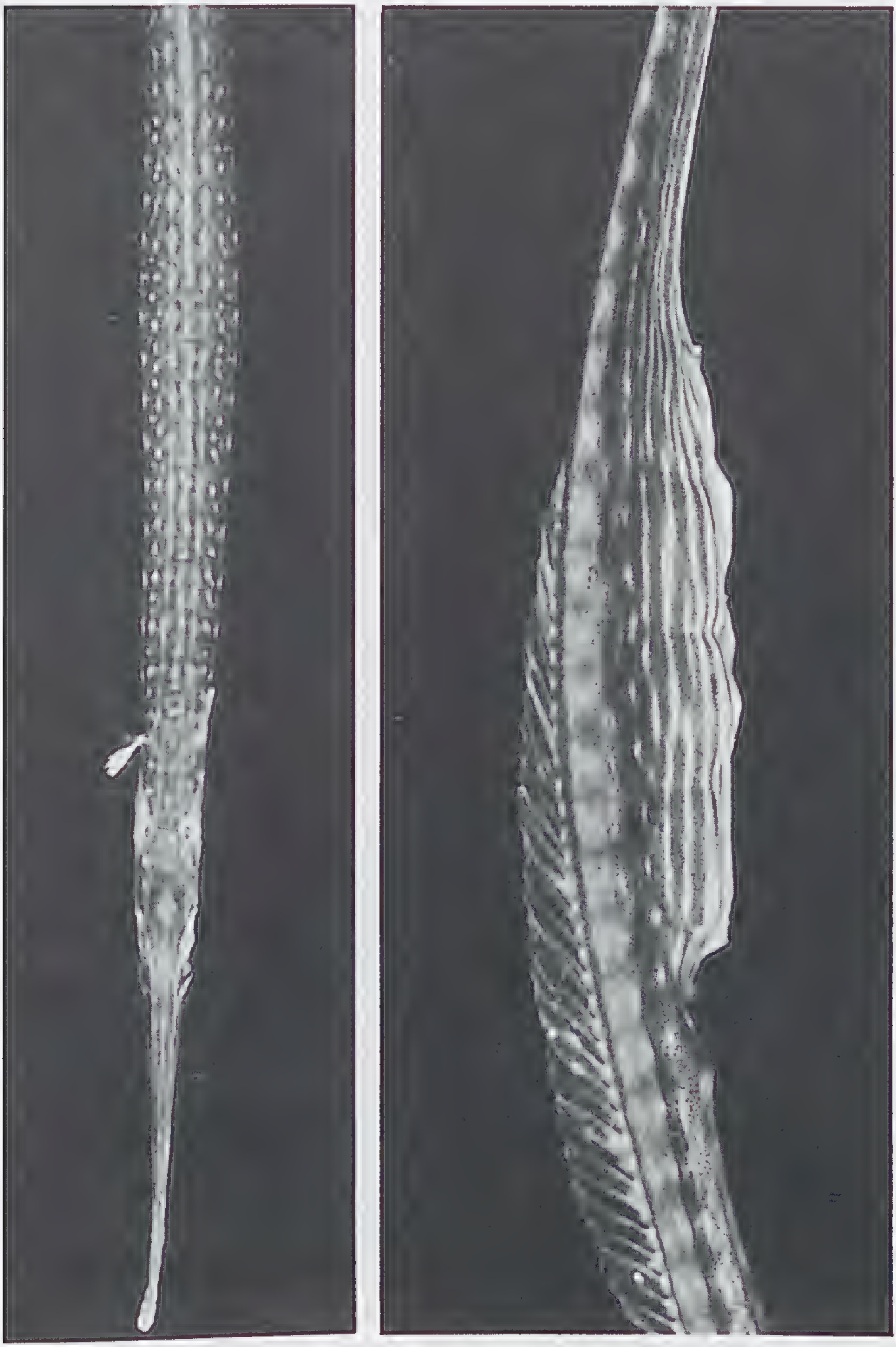

Fig. 4. *Stigmatopora argus.* Top — Dorsal aspect of head and anterior portion of trunk of 149 mm TL adult male (GCRL 16376). Bottom — Lateral aspect of section of body of 94.5 mm TL brooding male illustrating striped pattern on pouch folds.

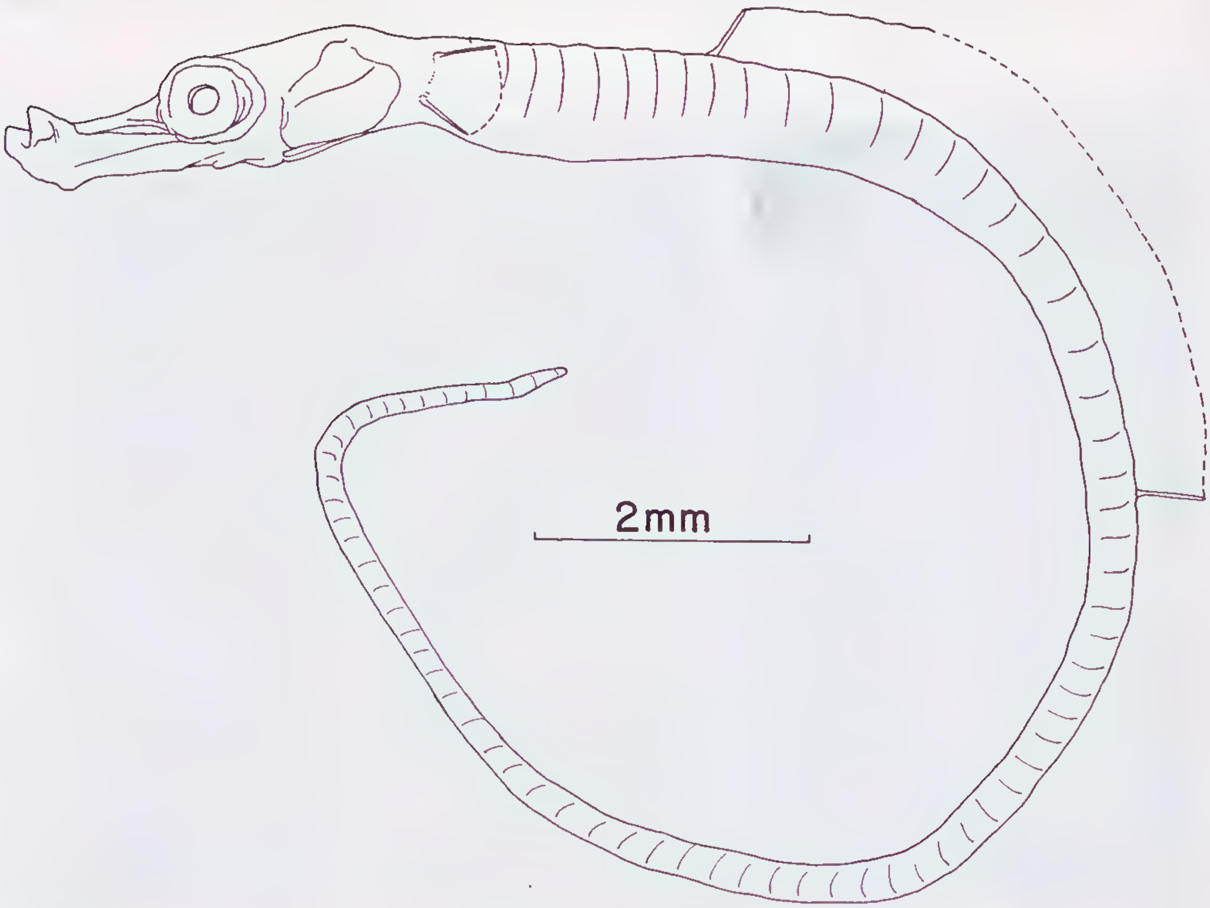

Fig. 5. Partially straightened 20.4 mm TL pouch larva of *Stigmatopora argus* (GCRL 16306).

Compared to its New Zealand congener, *S. argus* has a shorter lateral trunk ridge (crosses an average of 12.6 tail rings versus 28.1 in *macropterygia*), fewer subdorsal rings (14.75-22.75 versus 23.25-26.5) and fewer dorsal-fin rays (37-64 versus 63-74). The spotted coloration and striped brood pouch occurring in many adult *S. argus* do not occur in *S. macropterygia* and adult females of the latter usually have well-developed fleshy folds on the lateral ridge (uncommon in *argus*). Finally, *S. argus* is a smaller form which fails to approach the maximum observed length of *S. macropterygia* (ca. 350 mm TL). Shared characters, such as the relatively long lateral trunk ridge, the more common occurrence of the fleshy lateral ridge fold and the low trunk depth in breadth ratio of adult females, suggest that these species are more closely related than either is to *S. nigra*.

TYPES: The holotype of *Syngnathus argus* Richardson (BMNH 1855.9.19.1392) is a female (ca. 192 mm) which now lacks the anal fin as well as the tips of both the snout and the tail and has a damaged dorsal fin. Dark spots persist on the trunk and the lateral trunk ridge reaches to or near the 15th tail ring and bears a marginal fold (see Tables 1-5 for other data). I count 53 rather than the described 48 dorsal-fin rays, but the specimen otherwise agrees with Richardson's (1844) description in all important features.

Castelnau (1872b) diagnosed *Stigmatophora olivacea* as lacking a longitudinal opercular ridge and having the vent below the middle of the dorsal-fin, 19 body rings, 13 pouch rings and olive coloration. The emended diagnosis (Castelnau, 1873) stated

that there were about 84 tail rings and 45 dorsal-fin rays, that there were 18 pectoral-fin rays, that the brood pouch was orange, that the total length was nine inches (228.6 mm). Neither diagnosis suggests that Castelnau had more than a single male specimen of *S. olivacea.* The Paris collection now contains a damaged male specimen (MNHN A.738) catalogued as *"Stigmatophora olivacea,* Adelaide, Castelnau." The snout and tail are broken, the distal extremity of the tail is missing and the estimated length of the extant portion is about 220 mm. There are 19 trunk rings, 75 remaining tail rings, 45 dorsal-fin rays, 17 pectoral-fin rays, 8.5 + 7.75 subdorsal rings, eggs are present through 11 of 18 pouch-rings and coloration is plain except for faint indications of stripes on the pouch folds. The present count of 18 pouch-rings is greater than that given for the holotype but the count of 11 egg-bearing pouch rings more closely agrees with Castelnau's pouch-ring count of 13. This specimen closely approaches Castelnau's description in respect to size, counts and coloration and I consider it the presumptive holotype of *Stigmatophora Olivacea.*

The holotype of *Stigmatophora unicolor* Castelnau 1875 (MNHN A.737), a species formerly referred to the synonymy of *Stigmatopora argus,* is actually a specimen of *Syngnathoides biaculeatus* (Bloch).

The holotype of *Stigmatophora depressiuscula* (AMS I.16289-001) is a male of indeterminable length which now lacks much of the head and tail and all fins are damaged. The specimen has 19 trunk rings and about 8 + 10 subdorsal rings.

I have been unable to locate the types of *Gastrotokeus gracilis* Klunzinger, *Stigmatophora gracilis* Macleay or *Stigmatophora argus* var. *brevicaudata* Lucas.

REMARKS: The free dorsal edge of each pouch fold bears a thin, dorsally directed, narrow membrane and the ventral edge bears a wider, largely adnate, out-turned membranous fold. The brood pouch extends below the anterior 14-24 tail rings in 27 examined males; the smallest male with evidence of pouch development is about 95.5 mm TL. Among 12 brooding fish (ca. 112-230 mm TL) the pouch extends below 15-20 rings and eggs are deposited in 2-4 transverse rows through the 10-19 anterior pouch-rings. The 112 mm fish contained a total of 15 eggs through 11 of 18 pouch rings while the 230 mm specimen had 41 eggs through 16 of 20 pouch rings. The pouches of examined males were never completely filled with eggs, and membranous egg compartments were never developed through the entire pouch length. Maximum egg diameter was 1.8 mm in a 140 mm TL male and pouch larvae (Fig. 5) measured ca. 20.4 mm TL in one fish (ca. 133 mm TL) from South Australia. Study material includes brooding males taken in Jan., Mar., Apr. and July-Oct.

The holotype and ten other adult females (ca. 122.5-159 mm TL) had narrow to moderately broad fleshy folds on the lateral trunk ridges.

GEOGRAPHIC VARIATION: Material examined fail to show significant geographic variation in proportional values or coloration but such variation is indicated for a number of meristic features (Tables 1-5). Additional data are required for adequate analysis, but fish from Tasmania and Western Australia have somewhat higher counts of trunk rings, pectoral and dorsal fin rays and subdorsal trunk rings than those from other areas. Tasmanian fish have the highest frequencies of total subdorsal rings. Four badly damaged large fish (SAM F.3609), reportedly collected "off Cape Douglas, SA," have counts (omitted from Tables) which agree with the Tasmanian population. Other South Australian fish closely approach samples from Victoria and New South Wales in most meristic values and these atypical specimens may well be of Tasmanian origin. Present clinal variation in meristic values is replicated to a greater or lesser degree in

several other species of pipefishes which range along southern Australian coasts from Queensland to Western Australia.

Although detailed information on depth and method of capture is lacking for many samples, present materials suggest that the largest specimens of *S. argus* occur in Tasmania and Western Australia. At least 12 of the 28 fish examined from these areas ranged from 200-225 mm TL. Excepting the questionable specimens in SAM F.3609 (one at least 227 mm), none of the hundred fish examined from South Australia, Victoria and New South Wales exceeded 195 mm TL. Furthermore, Tasmanian and Western Australian adults seem to have somewhat better development of the opercular ridge than adults from other areas.

DISTRIBUTION: A number of literature records from Australia and other localities are probably erroneous. All records from New Guinea are evidently based on Kaup (1856) and those from Darwin are based on Klunzinger (1879) but these have not been confirmed by subsequent collections. Fowler's Fiji records (1907 (as *nigra*), 1922, 1959) were doubtless based on mislabelled Australian specimens, and Carcasson's (1977) references to Indonesia and Melanesia cannot be substantiated here. I have been unable to verify Munro's (1958a) record from S. Queensland and Duncker's (1909) record from Barrow I. (ca. 20°46′S, 115°24′E) is questionable.

Based on examined material, *S. argus* is presently known from the southern half of Australia, ranging (Fig. 6) from the Hawkesbury River, New South Wales (ca. 33°30′S, 151°10′E) to Rottnest I. and Shark Bay, Western Australia (ca. 25°25′S, 113°35′E), including Tasmania. The species occurs among vegetation (*Zostera* sp., etc.) in shallow bays and estuaries and is also found in offshore waters. Maximum recorded capture depth is 8 m and a specimen (100 mm TL) has been taken (with *nigra*) among floating *Sargassum* sp. off Rottnest I. Although presently unknown from New Zealand, *S. argus* should be expected in protected waters, since *S. nigra*, formerly thought restricted to Australia, has recently been reported from this region (Dawson, 1980a).

MATERIAL EXAMINED: 130 specimens (excluding pouch larvae), 66-254 mm TL, including holotype.

HOLOTYPE: BMNH 1855.9.19.1392 (192 mm, damaged female), "exact habitat unknown", "presented . . . by the surgeon of a convict ship", probably Tasmania.

OTHER MATERIAL: AUSTRALIA, New South Wales: AMS I.17034-002 (2, 122.5-175.5), AMS I.19938-007 (1, 154.5), AMS I.20021-001 (3, 145-160.5), AMS I.20040-004 (4, 133-157), AMS I.20044-006 (3, 138-151), GCRL 15521 (2, 115-129), GCRL 16370 (2, 128-139.5), GCRL 16374 (4, 86-130), GCRL 16375 (6, 95-114), GCRL 16376 (9, 98-149), NMV 54336-41 (6, 166-196), QM I.441 (7, 138-185). Victoria: AMS I.19785-006 (1, 152.5), MCZ 52361 (1, 115), NMV A.608 (4, 95-132), NMV A.609 (1, 66), NMV A.610 (1, 126), NMV A.611 (1, 130), NMV A.612 (1, 114), NMV A.613 (1, 100), NMV A.614 (3, 120-130), NMV A.615 (1, 97), NMV A.616 (1, 114), NMV A.617 (1, 97.5), NMV A.618 (1, 88), NMV A.619 (2, 92-120), NMV A.620 (1, 126), NMV A.621 (2, 136-157), NMV A.622 (3, 98-106), NMV A.623 (2, 114-116), NMV A.671 (6, 112-133.5). South Australia: AMS I.20179-016 (6, 80-165), AMS I.20180-020 (2, 103.5-190), MNHN A.738 (ca. 220, damaged male, presumptive holotype of *Stigmatophora olivacea*), QM I.9828 (2, damaged), SAM F.3588 (1, 90), SAM F.3632 (1, 108), SAM F.4136 (8, 105-159), SAM F.3609 (4, damaged). Tasmania: BMNH 1860.11.29.58-59 (2, 168-177), BMNH 1872.9.9.9-10 (2, 172.5-178), GCRL 14764 (1, 165), QVM 1974/5/37 (1, 181), QVM 1978/5/89 (3, 195-254.5). Western Australia: AMS I.16289-001 (damaged male holotype of *S. depressiuscula*), BMNH 1935.9.14.5 (1, 150.5), GCRL 16461 (1, 99), NMV A.607 (1, 225), WAM P.25258-014

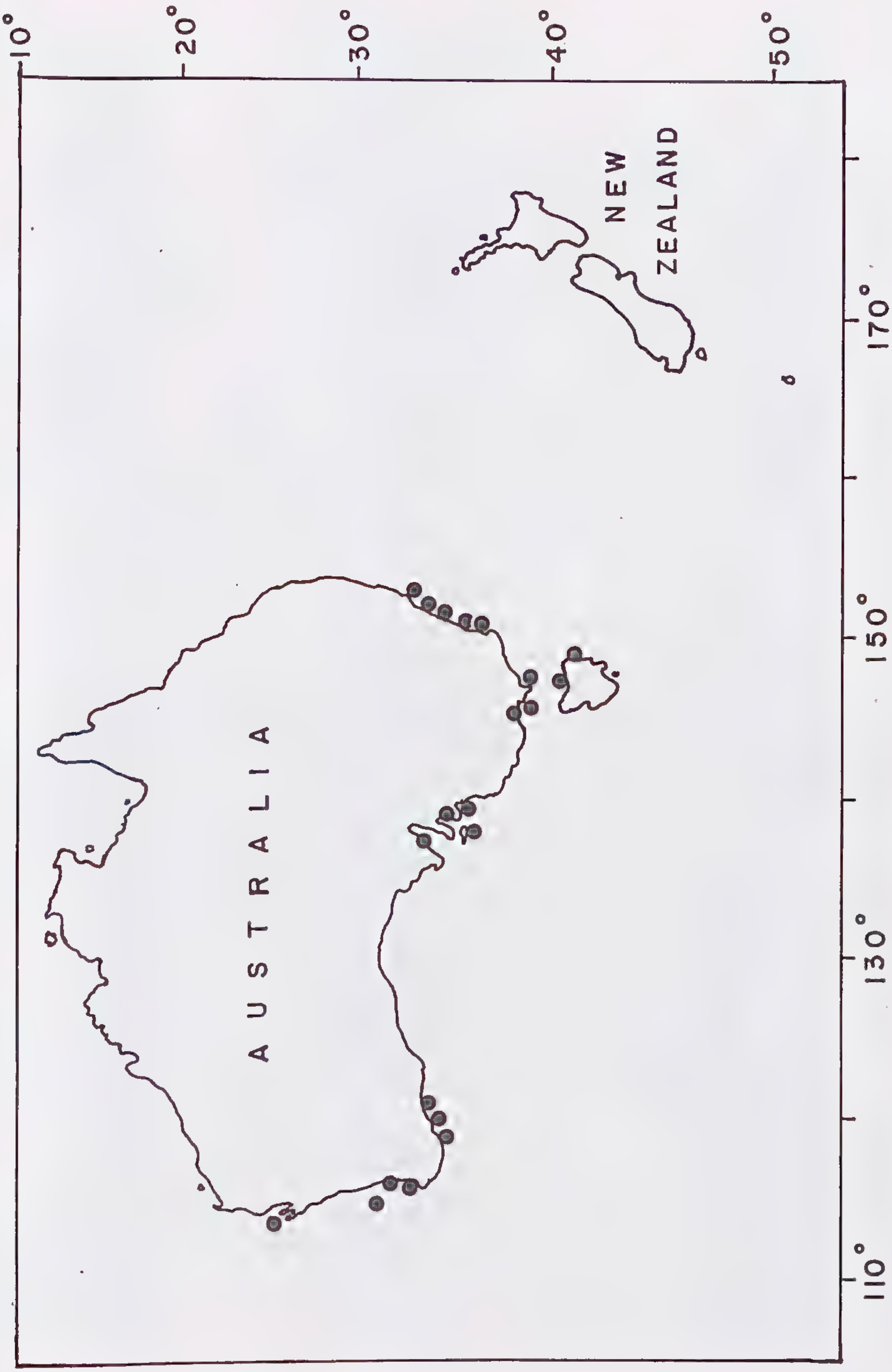

Fig. 6. Distribution of *Stigmatopora argus* based on material examined. Each symbol indicates approximate locality of one or more collections.

(3, 147-168.5), WAM P.25259-002 (4, 217-250), WAM P.25752-004 (1, 195.5), WAM P.26466-001 (2, 221-243).

Stigmatopora nigra Kaup
Figs. 7, 8

Stigmatopora niger Kaup, 1853:233 (nomen nudum).

Stigmatophora nigra Kaup, 1856:53 (orig. descr.; Tas.); Duméril, 1870:583 (descr.); Günther, 1870:190 (descr.); Castelnau, 1875:48 (Adelaide); Castelnau, 1879:355, 360 (Port Jackson; Austr., endemic); Macleay, 1882:297 (descr.; Port Jackson, Port Phillip); Tenison-Woods, 1882:23 (compiled); Johnston, 1883:134 (Tamar, Tas.); Johnston, 1890:37 (compiled); Lucus, 1890:39 (compiled); Schreiner and Miranda Ribeiro, 1903:87 (listed); Ogilby, 1912:36 (Qld.); McCulloch, 1914:29, figs. 1-3 (sexual dimorphism; comparisons; Tas.); Duncker, 1915:103 (descr.; SA, Tas.); Whitley, 1927:4 (listed, Fiji); Fowler, 1931:323 (listed, Fiji); Bertin and Estéve, 1950:49 (syntype listed as holotype); Munro, 1958a:90, fig. 623 (descr.; distr.); Scott, 1961:60 (in key; Tas.); Marshall, 1964:120, pl. 28 (in key; descr.; distr.); Breder and Rosen, 1966:294 (ref.); Marshall, 1966:177, pl. 28, fig. 129 a-c (colour note; S. Qld.); Scott et al., 1974:123, figs. (in key; descr.; distr.); Shiino, 1976:109 (compiled); Glover, 1979:150 (Kangaroo I.); Scott, 1980:106 (listed, Tas.).

Stigmataphora nigra. Castelnau, 1872:201 (misspelling; descr.; Melbourne).

Stigmataphora boops. Castelnau, 1872:203 (nomen nudum; Melbourne).

Syngnathus pelagicus (not of Linnaeus). Zietz, 1908:298 (misident.; SA).

?*Stigmatophora nigra*. Duncker, 1909:239 (counts; Vic., Tas.)

Stigmatopora nigra. McCulloch, 1921:37, fig. 966 (compiled; NSW); Waite and Hale, 1921:311, fig. 49 (descr.; distr.); Lord, 1923:64 (listed, Tas.); Lord and Scott, 1924:40 (fairly common; Tas.); McCulloch and Whitley, 1925:137 (compiled); Lord, 1927:13 (listed, Tas.); McCulloch, 1929:93 (compiled); Scott, 1939:139, 142 (in key); Whitley, 1951:62 (type-species of *Pipettella* subgen. nov.); Whitley, 1953:135 (type-species of *Nigracus* gen. nov.); Scott, 1960:88 (nomenclatural notes); Scott, 1966:93 (note on anomalous opercular ridges); Scott, 1970:35 (compared with "*Ichthyocampus*" *cristatus*); Lenanton, 1974:8, 14 (compiled; WA); Scott, 1977:123 (ref. to operc. ridge); Dawson, 1980a:288, fig. 6 (diagnosis, New Zealand).

Nigracus nigra. Whitley, 1953:135 (n. comb.; type-species of *Nigracus* gen. nov.); Whitley and Allan, 1958:61, fig. (compiled); Whitley, 1964:38 (compiled).

DIAGNOSIS: Dorsal-fin origin on 5th-7th trunk ring; lateral trunk ridge not continued past 2nd tail ring; pectoral-fin rays usually (95%) 11-14; usually with dark bilateral stripes on underside of head; without well-defined spots or ocelli on dorsum of trunk.

DESCRIPTION: Trunk rings 16-19; tail rings 67-79 (10 counts); dorsal-fin rays 35-47; pectoral-fin rays 11-16; dorsal-fin origin on 5th-7th (usually 6th) trunk ring; subdorsal rings 13.5-10.5 + 4.25-8.75 = 15.75-20.75; lateral trunk ridge usually ends on anal ring or 1st tail ring; see Tables 1-5 for additional counts. Proportional data based on 26 specimens 9.9-20.3 ($\bar{x}$ = 14.5) mm HL follow: snout length in HL 1.5-1.8 (1.7), snout depth in snout length 7.5-18.7 (10.2), length of dorsal-fin base in HL 0.5-0.8 (0.6), anal ring depth in HL 6.9-13.0 (9.2), trunk depth in HL 4.6-11.0 (7.8), pectoral-fin length in HL 6.4-8.4 (7.2), length of pectoral-fin base in pectoral-fin length 1.3-2.3 (1.7).

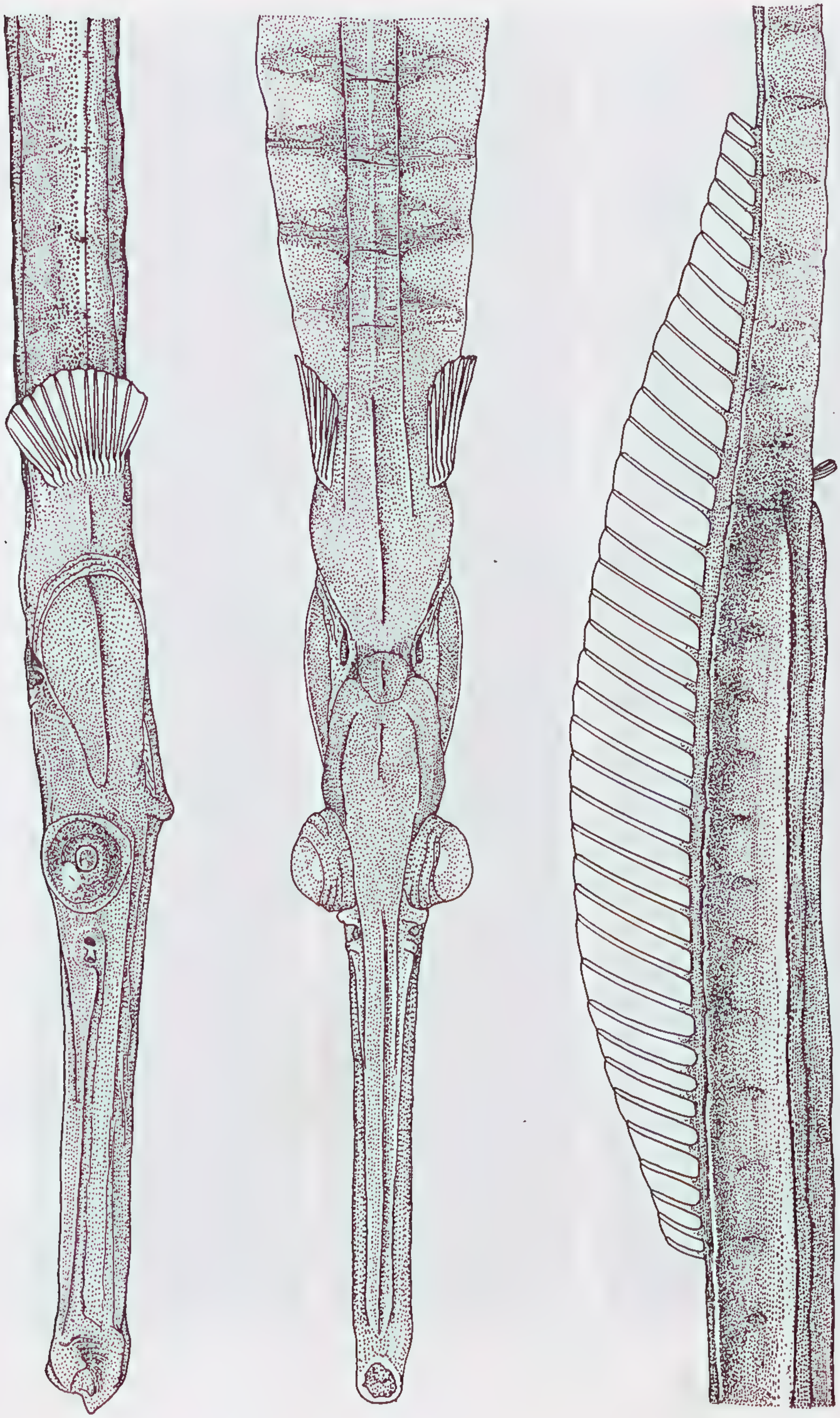

Fig. 7. *Stigmatopora nigra*. Lateral and dorsal aspects of head and anterior trunk rings, together with section of body illustrating ridge configuration and dorsal and anal fins. From 98.5 mm TL adult female (GCRL 16369).

Fig. 8. *Stigmatopora nigra*. Top — Lateral aspect of 68 mm TL brooding male (GCRL 16372). Middle — Dorsal aspect of head and anterior portion of body of 138.5 mm TL adult female (NMNZ 7964). Bottom — Ventral aspect of head and anterior portion of body of 99.5 mm TL adult female (NMV A.673).

Opercular ridge usually rather prominent, complete or nearly complete in young and adults. Trunk depth in breadth ratio clearly sexually dimorphic in adults, averages 1.4 in males and 2.2 in females; adult females seldom with marginal fleshy fold on lateral trunk ridge.

COLORATION: Ground colour gray to dark brown in adults, pale in pelagic juveniles; adults with dorsum and sides of head brownish, sometimes blotched with pale; venter of head brown in front, with a pale medium area behind vertical through anterior rim of orbit and with narrow dark bilateral stripes crossing suborbital and lower part of opercle (Fig. 8); dorsum of trunk plain or blotched with brown, usually lighter than upper half of sides; lateral trunk ridge usually pale in mature females; ventral surface of trunk pale to dark brown, usually with indications of dark bars between rings; brood-pouch folds often with pale margins, otherwise plain brown or with a few irregular minute flecks of pale or dark brown; remainder of tail plain, irregularly blotched or with indications of narrow bands of pale and brown; fin rays usually edged or flecked with brown.

COMPARISONS: Compared to its New Zealand congener, *S. nigra* has fewer trunk rings (modally 17 against 21 in *macropterygia*), a more anterior dorsal-fin origin (on 5th-7th trunk ring versus 8th-10th), lower counts of subdorsal tail rings and total subdorsal rings (respectively, 4.5-9.0 and 15.75-21.0 versus 10.5-13.5 and 23.25-26.25) and a shorter lateral trunk ridge (ends near anal ring in *nigra*, on 25th-32nd tail ring in *macropterygia*). Adult females have a broadly expanded trunk (moderately so in *macropterygia*) and typically lack of fleshy fold on the lateral trunk ridge (typically present in *macropterygia*). Furthermore, maximum observed length of *S. nigra* (ca. 162 mm) is much less than that of *S. macropterygia* (ca. 350 mm).

For other comparisons see this section under *S. argus*.

TYPES: Kaup's (1856) two syntypes of *S. nigra*, then located in the Paris collection, included at least one adult male but lengths were not indicated. Later, Duméril (1870) noted that the Paris collection included only a 110 mm female specimen of *S. nigra*, and Bertin and Estéve (1950) listed a specimen of this length and sex as the holotype of *S. nigra* (MNHN 6055). Recent examination shows MNHN 6055 to contain a single male of this species which lacks part of the tail and measures about 84 mm TL. This fish has 17 trunk rings, about 21 tail rings, about 40 dorsal-fin rays, 13 pectoral-fin rays, 11.25 + 5.25 subdorsal rings and 14 pouch rings. These values agree with or approximate those given by Kaup and this specimen is here treated as a presumptive syntype of *S. nigra*. The female specimen mentioned by Duméril (1870) and Bertin and Estéve (1950) cannot be located in the Paris collection and its fate is unknown.

Bertin and Estéve (1950) listed 10 specimens (50-60 mm) as paratypes of *Stigmatophora boops* Castelnau (MNHN A.1435). These have recently been shown (Dawson, 1980b) to be syntypes of *Urocampus carinirostris* Castelnau.

REMARKS: The outer dorsal edges of the pouch folds lack the narrow dorsally directed membranes found in *S. argus*. The free margins of the pouch are sometimes simple but they usually bear a narrow ventrally or laterally directed fold. The brood-pouch extends below the anterior 12-16 tail rings in 19 males examined. The length range of 12 brooding fish was 68-108 mm TL with the smallest male having evidence of pouch development measuring ca. 57 mm TL. Eggs are in 1-4 transverse rows with the inner rows often irregular or incomplete. One male (80 mm) had a total of 20 eggs through 9 of 12 pouch rings, while another (77.5 mm) had 41 early embryos through 11 of 14 rings and a third (68 mm) had 14 late larvae (ca. 8.8 mm) within a 15

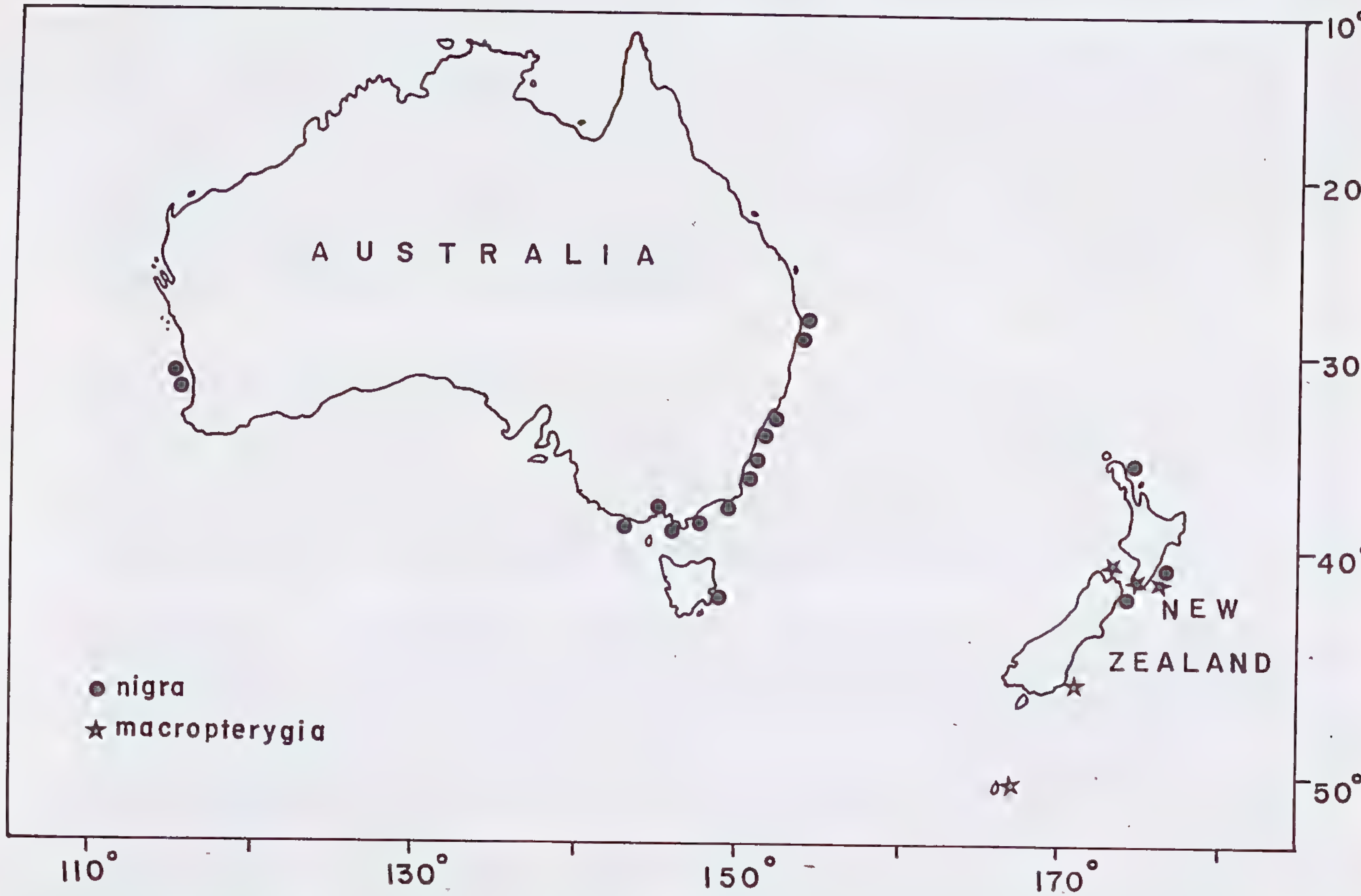

Fig. 9. Distribution of *Stigmatopora nigra* and *S. macropterygia* based on material examined. Each symbol indicates approximate locality of one or more collections.

ring pouch. Brooding Australian fish were taken during Feb., Apr.-June and Aug.-Oct. The smallest examined female with a clearly expanded trunk was ca. 69 mm TL. A fleshy marginal fold was clearly evident on the lateral ridge of only one adult female.

The bilateral dark stripes on the underside of the head may be faint or obscured by an exceptionally dark ground colour but some indication of their presence persists in most well-preserved material.

GEOGRAPHIC VARIATION: I fail to find evidence of geographic variation in coloration of proportional features, and meristic data (Tables 1-5) show few major differences between compared Australian populations. Still, trunk ring counts average a little higher in material from Victoria, counts of pectoral-fin rays are a little lower in the Tasmanian sample, while counts of dorsal-fin rays are lower in Queensland and Western Australia and highest in Tasmania. Additional study is required to determine the validity of these apparent differences.

Compared to the Australian population, New Zealand material has higher counts of subdorsal trunk rings and total subdorsal rings (respectively, 6.75-9.0 and 18.75-21.0 versus 4.5-7.5 and 15.75-19.5). The New Zealand fish agree with Tasmanian specimens in the relatively high counts of dorsal-fin rays, with Western Australian samples in the lower counts of pectoral-fin rays and have a tendency toward higher trunk ring counts than the majority of Australian specimens.

DISTRIBUTION: Whitley's (1927) reference to Fiji was based on Fowler's (1907) misidentification of mislabelled specimens of *S. argus;* Fowler's (1931) record is from Whitley (1927).

Stigmatopora nigra is presently known (Fig. 9) from the vicinity of Tangalooma Pt., S. Queensland (ca. 27°12'S, 153°22'E) south and west to the offings of Rottnest I., Western Australia (ca. 32°02'S, 115°36'E), from Tasmania and from New Zealand. The species frequents shallow bays and estuaries (among vegetation) as well as offshore waters where specimens are recorded from trawl and dredge collections to a maximum depth of 35 m. Juveniles and adults (35-67 mm TL) have been collected from floating *Sargassum* sp. off Rottnest I.

MATERIAL EXAMINED: 97 specimens (excluding pouch larvae), 35-162 mm TL, including one presumptive syntype.

PRESUMPTIVE SYNTYPE: MNHN 6055 (84 mm, damaged male), Tasmania, M. Verreaux.

OTHER MATERIAL: AUSTRALIA, Queensland: QM I.7751 (1, 75), QM I.1608 (1, 100), QM I.11273 (1, 63), QM I.13400 (3, 73-85). New South Wales: AMS I.16498-006 (1, 102.5), AMS I.17817-001 (1, 109), AMS I.17895-002 (6, 67-100), AMS I.19933-001 (2, 63-74.5), AMS I.19948-002 (1, 83), AMS I.20044-001 (2, 90-91), AMS I.20049-010 (9, 67-128), GCRL 16369 (5, 72.5-101), GCRL 16372 (3, 37.5-75). Victoria: AMS I. 19782-001 (2, 94.5-101), NMV A.550 (1, 113), NMV A.598 (1, 69), NMV A.599 (1, 162), NMV A.600 (1, 80), NMV A.601 (2, 59-72.5), NMV A.602 (1, 57), NMV A.603 (1, 80), NMV A.673 (8, 78-106). Tasmania: GCRL 15522 (5, 80-114). Western Australia: GCRL 16460 (15, 35-67), NMV A.604 (2, 70-80), WAM P.25343-002 (1, 116), WAM P.25344-009 (3, 83.5-107), WAM P.25346-013 (3, 74-91), WAM P.25804-002 (5, 97-113). NEW ZEALAND, North I.: NMNZ 1261 (2, 89-140.5), NMNZ 7963 (1, 92.5), NMNZ 7964 (1, 138.5). South I.: GCRL 16313 (1, 94.5), NMNZ 1077 (3, 75.5-88).

Stigmatopora macropterygia Duméril
Figs. 10, 11

Stigmatophora macropterygia Duméril, 1870:583 (orig. descr.; Oceania); Duncker, 1915:104 (descr.; New Zealand); Fowler, 1928:112 (ref.); Bertin and Estéve, 1950:50 (holotype listed).

Stigmatophora longirostris Hutton, 1872:68 (orig. descr.; Wellington Harbour); Gill, 1893:122 (compiled); Hutton, 1904:52 (compiled); Phillips, 1927:11 (compiled); Whitley, 1955:119 (listed as snr synon. of *S. gracilis*); Heath and Moreland, 1967:16, fig. (ref.); Morton and Miller, 1968:199, fig. (among tidal algae).

Stigmatopora longirostris. Waite, 1907:14 (compiled); Whitley, 1968:35 (compiled); Russell, 1969:108 (among intertidal algae).

Stigmatopora macropterygia. Dawson, 1980a:288, fig. 7 (diagnosis, comparisons).

DIAGNOSIS: Dorsal-fin origin on 8th-10th trunk ring; lateral trunk ridge reaches 22nd-35th tail ring; pectoral-fin rays usually (96%) 16-19; without stripes on underside of head; dorsum of trunk with or without bilateral dark spots between rings.

DESCRIPTION: Trunk rings 21-22; tail rings 85-92 (7 counts); dorsal-fin rays 63-74; pectoral-fin rays 15-19; dorsal-fin origin on 8th-10th trunk ring; subdorsal rings 13.5-11.5 + 10.5-13.75 = 23.0-26.25; lateral trunk ridge reaches 22nd-35th ($\bar{x}$ = 28.1) tail ring; see Tables 1-5 for additional counts. Proportional data based on 26 specimens 13.4-52.8 ($\bar{x}$ = 36.6) mm HL follow: snout length in HL 1.4-1.6 (1.5), snout depth in snout length 10.4-28.3 (17.3), length of dorsal-fin base in HL 0.5-0.7 (0.6), anal ring depth in HL 6.6-14.9 (9.1), trunk depth in HL 6.2-10.0 (7.8), pectoral-fin length in HL 7.9-12.9 (9.4), length of pectoral-fin base in pectoral-fin length 1.0-1.7 (1.3).

Opercular ridge low, complete in juveniles (82 mm TL), sometimes incomplete in adults; trunk depth of adults 1.2-1.7 (1.3) in trunk breadth, the ratio not strongly sexually dimorphic. Females (larger than 216 mm) usually with a fleshy marginal fold on the lateral ridge, fold widest (to ca. 3 mm) on tail and posterior part of trunk.

COLORATION: Subadults and adults gray to dark brown, the venter usually lighter than sides and dorsum; often without distinctive markings but some specimens have bilateral dark spots on the superior ridges between some or most trunk rings, whereas others retain traces of faint bands on the trunk; brood-pouch folds without distinctive markings; marginal fold on lateral ridge of adult females often plain, sometimes narrowly edged or scalloped with black; fin rays usually edged with brown. Juveniles (ca. 80-115 mm TL) pale, with irregular scattering of microchromatophores and hyaline fins.

TYPES: Duméril reported 68 dorsal-fin rays and 13 + 13 subdorsal rings in the damaged holotype of *S. macropterygia*. This juvenile or female specimen (MNHN 6054) is now in two pieces (estimated combined length ca. 170 mm) and in very poor state of preservation. The dorsal fin originates on the 8th trunk ring and I count 65 dorsal-fin rays and 11 + 13.25 subdorsal rings.

The original description of *S. longirostris* was based on at least one adult male and at least one "young." The species was described as common, reaching a length of 14 inches (355.6 mm) and having 21 + 71 rings and 66-67 dorsal-fin rays. A juvenile or young female and an adult female (BMHN 74.4.26.8) labelled "Wellington, received

Fig. 10. *Stigmatopora macropterygia*. Lateral and dorsal aspects of head and anterior trunk rings, together with section of body illustrating ridge configuration and posterior portion of dorsal fin. From 255 mm TL adult male (GCRL 15083).

Fig. 11. *Stigmatopora macropterygia*. Lateral aspect of head and anterior portion of body of 255 mm TL adult male (GCRL 15083).

from the New Zealand Institute, Wellington," are considered presumptive syntypes. Both lack distal portions of the tail, and have 21-22 trunk rings and 67-69 dorsal-fin rays. The adult retains paired dark spots on the dorsum as noted in the original description. The fate of the male syntype(s) is unknown.

REMARKS: Part of the tail was missing in each of the seven adult males examined. Margins of pouch folds appeared to be simple with the brood-pouch developed below 21-24 anterior tail rings. Eggs were not present but embryos and pouch larvae (ca. 20.2 mm) were retained in three fish. One specimen had at least five transverse rows of membranous egg compartments and about 32 compartments in the outer right row. Data are not available on brooding season.

GEOGRAPHIC VARIATION: Available material shows no evidence of geographic variation.

DISTRIBUTION: This species is known only from New Zealand and the Auckland Is. (Fig. 9). Present material includes New Zealand specimens collected from Otago Harbour (South Island) to Castel Point (North Island). Most seem to have been collected near wharves or piling; maximum recorded depth is 7.3 m.

MATERIAL EXAMINED: 37 specimens (excluding pouch larvae), 82-349.5 mm TL, including holotype.

HOLOTYPE: MNHN 6054 (damaged juvenile or female), Oceania, Arnoux.

OTHER MATERIAL: NEW ZEALAND: BMNH 74.4.26.8 (2, 127-279.5, presumptive syntypes of *Stigmatophora longirostris*), BMNH 1886.11.18.104 (1, 190), GCRL 15083 (2, 255-257), GCRL 16310 (1, 339.5), GCRL 16311 (1, 282), GCRL 16330 (1, 82), NMNZ 291 (1, 117), NMNZ 519 (1, 278), NMNZ 688 (1, 293.5), NMNZ 743 (1, 254), NMNZ 850 (2, 199-203), NMNZ 1197 (1, 349.5), NMNZ 1240 (2, 188.5-229.5), NMNZ 1265 (1, 159.5), NMNZ 1615 (1, 290.5) NMNZ 1700 (1, 240), NMNZ 1762 (1, 259.5) NMNZ 2097 (2, 228-287), NMNZ 2177 (1, 100.5), NMNZ 2312 (1, 311), NMNZ 2544 (1, 261.5), NMNZ 2715 (1, 332), NMNZ 2716 (3, 132-244.5), NMNZ 3190 (1, 256), NMNZ 3276 (2, 216-235), NMNZ 4203 (1, 296), NMNZ 7972 (1, 272). AUCKLAND IS.: NMNZ 3325 (1, 107).

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TABLE 1. Frequency distributions of trunk rings, site of dorsal-fin origin and pectoral-fin rays in species of *Stigmatopora*. Except where indicated, data are not available for primary types.

Species	Trunk rings								Dorsal-fin origin on trunk ring									Pectoral-fin rays								
Locale	16	17	18	19	20	21	22	23	5	6	7	8	9	10	11	12	13	11	12	13	14	15	16	17	18	19
nigra																										
Australia																										
Qld.		5								5										1		1				
NSW	3	21	3						4	12									1	27	10					
Vic.	3	8	8						1	12	3								4	8	9	3	1			
Tas.		4*	2							4	1							3	1	2*						
WA	1	10							3	9											2					
New Zealand		3	5	1						2								5	8	3						
argus																										
Australia																										
NSW		4	24	13	1									7	24	1				2	15	15	9	9		
Vic.	1	5	8	15	3								1	9	20	2				1	4	16	7			
SA	2	6	2	4	3	3							3	5	2					1		14	14	1	2	
Tas.				3	7*								1	3	5*							4*	7	3		
WA				1	4	3	4	2						1	3	7	2					7	10	2		
macropterygia																										
New Zealand						21	12					1*	1	5								2	26	18	5	1

*Primary type

TABLE 2. Frequency distributions of dorsal-fin rays in species of *Stigmatopora*. Except where indicated, data are not available for primary types.

Species / Locale	36	39	42	45	48	51	54	57	60	63	66	69	72	75
	Dorsal-fin rays													
nigra														
Australia														
Qld.	11	4												
NSW	4	18	7											
Vic.	3	11	1											
Tas.			2	3										
WA	10	1												
New Zealand			4	3	2									
argus														
Australia														
NSW			1	17	16	5	2							
Vic.	1	1	5	8	6		1							
SA		1	6	2	5	2								
Tas.						1	1*	4	2					
WA					3	6	1	2						
macropterygia														
New Zealand										2	15*	6	7	1

*Primary type.

TABLE 3. Frequency distributions of subdorsal trunk rings in species of *Stigmatopora*.

Species / Locale	13.5	12.75	12.0	11.25	10.5	9.75	9.0	8.25	7.5	6.75	6.0
	Subdorsal trunk rings										
nigra											
Australia											
Qld.		1	4								
NSW		5	11	9	2						
Vic.		2	6	8							
Tas.			1	5*							
WA			4	7							
New Zealand	1	3		5							
argus											
Australia											
NSW						2	8	19	10	2	
Vic.						1	5	13	6	1	1
SA						1	4	8	2	1	
Tas.					3	5*	1	1			
WA				1	6	4	2	1			
macropterygia											
New Zealand	5	12	16	1*							

*Primary type.

TABLE 4. Frequency distributions of subdorsal tail rings in species of *Stigmatopora*.

Species Locale	Subdorsal tail rings 4.5	5.25	6.0	6.75	7.5	8.25	9.0	9.75	10.5	11.25	12.0	12.75	13.5
nigra													
Australia													
Qld.		3	1	1									
NSW		5	12	9	1								
Vic.		3	9	4									
Tas.		2*	2	2									
WA	2	5	4										
New Zealand				1	4	3	1						
argus													
Australia													
NSW					3	11	11	15	1				
Vic.					2	10	9	6					
SA				1	3	4	2	5	1				
Tas.						1*		2	1	3	3		
WA				1	4	5	3	1					
macropterygia													
New Zealand									1	7	12	11	3*

*Primary type.

TABLE 5. Frequency distributions of total subdorsal rings in species of *Stigmatopora*.

Species Locale	Total subdorsal rings 15.0	15.75	16.5	17.25	18.0	18.75	19.5	20.25	21.0	21.75	22.5	23.25	24.0	24.75	25.5	26.25
nigra																
Australia																
Qld.				2	2	1										
NSW			2	6	12	5	2									
Vic.			3	4	6	3										
Tas.			2*	2	1	1										
WA		1	4	3	3											
New Zealand						3	2	3	1							
argus																
Australia																
NSW		5	8	11	11	6										
Vic.	3	4	5	7	6	2										
SA	2	6		1		7										
Tas.						1*		3	4	1	1					
WA				2	6	6										
macropterygia																
New Zealand												7	6*	9	7	5

*Primary type.

GALLOPING IN *CROCODYLUS JOHNSTONI* — A REFLECTION OF TERRESTRIAL ACTIVITY?

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SUMMARY

Crocodylus johnstoni commonly gallop when released after being caught and handled. Galloping is a bounding gait and, in addition to increased velocities, it allows crocodilians to rapidly negotiate obstacles such as rocks and logs when on land. Bound length and gallop velocity both increase with increasing snout–vent length, but not in the same proportion: small *C. johnstoni* bound more frequently than larger ones.

INTRODUCTION

Although living crocodilians may spend appreciable portions of the day and night on land, the terrestrial excursions of most species rarely extend far from water. The observations of Cott (1961) that "when disturbed ashore a Nile crocodile's immediate reaction is to make for water with speed" may be applied to most crocodilians. Yet the suite of terrestrial movement patterns (belly slide, high walk and gallop; Cott, 1961; Zug, 1974) shows little sophistication. Typically a disturbed crocodile will burst into a rapid high walk or belly slide (depending on the slope of the bank), sometimes colliding with trees and rocks before hitting the water "with tremendous impact" (Cott, 1961) and submerging. Galloping, as a form of crocodilian terrestrial locomotion, has been observed rarely (Cott, 1961; Zug, 1974), and then only in juveniles.

During a field study of *Crocodylus johnstoni,* the endemic Australian freshwater crocodile, it was found that individuals surprised on banks, and about 80% of 250 juveniles and adults released after being marked, galloped back to the water. As the gallop is spectacular, and had hitherto rarely been described in crocodilians, the opportunity was taken to collect preliminary data on it.

During the dry season (May to November), *C. johnstoni* frequently inhabits a variety of permanent and temporary pools, and overland travel between them seems commonplace, although there is little quantitative data on the frequency of such excursions. This paper describes the movement and attempts to interpret the common use of galloping by *C. johnstoni* as part of an adaptive suite reflecting greater terrestrial activity.

Records of the Australian Museum, 1982, **Volume 34 Number 14,** 607-618, Figures 1-4.

METHODS

This study was carried out during August/September, 1978, along the McKinlay River (131°30′E; 12°55′S), a major tributary of the Mary River System in the Northern Territory. At this time, the McKinlay River consisted of a river bed containing isolated pools separated by stretches of sand and rock. Many of these pools contained *C. johnstoni*, as did the semipermanent billabongs (= lagoons or remnants of oxbows) on either side of the main stream bed.

The crocodiles were being caught as part of a study of growth and movement (G. W.) and most were taken at night with fine nets (Webb and Messel, 1977). Until morning, they were individually tethered in the water, with heavy cord tied around and through the jaws. They were then measured, weighed, sexed, numbered (by removing a sequence of caudal scutes) and released; no anaesthetics were used.

Specimens were released on flat or sloping banks, and were annoyed until they moved to escape. They usually moved freely when they could see the water, though in some situations they turned and attempted to bite and could not be induced to 'escape' at any speed. Two tapes, colour marked at 50 cm and 1 m intervals were usually placed along the escape route.

Water temperatures and body temperatures were between 28° and 31°C; air temperatures in the shade were usually between 34° and 38°C.

Analysis of movement is based on 40 sequences of galloping (asymmetrical movement; Hildebrand, 1966) performed by individual *C. johnstoni* between 23 and 107 cm snout-vent length (SVL; approximately half total length if the tail tip is complete). Using a Nizo 801 Macro Camera, fifteen sequences were filmed at 24 f.p.s. from various angles between 1400 and 1700 hr on a clear day with intermittent cloud cover. An additional 25 sequences were recorded on 35 mm film with a motor-driven (3.4 f.p.s.) still camera and 300 mm lens. For comparison, 12 sequences of symmetrical movement were filmed with the movie camera at both 24 and 56 f.p.s. The cine films were analysed frame by frame on a Kodak Ektagraphic MFS 8 analytical projector. The stills were printed, joined in sequence, and then analysed. Distances travelled by animals between individual frames were measured using both the dimensions of each crocodile (head length in particular) and the colour-coded tapes as reference scales. Statistical methods follow Zar (1974).

RESULTS

A. TERRESTRIALITY

During August/September 1978, 269 *C. johnstoni* were caught in the McKinlay River area. The catching was essentially restricted to permanent and temporary pools, and when not actually catching, little time was spent in the area. Still, the following observations indicate that terrestrial activity is not unusual:

1. While catching in the drying pools of the mainstream, tracks leading from one pool to another over distances between 100 m and 400 m were common.

2. On 4 September, 1978 at 2030 hr a female *C. johnstoni* (SVL = 68 cm) was located on a gravel hill 53 m from a permanent pool. It was high walking towards the pool when encountered, and after being caught and released, galloped for 15 m, then shifted to a symmetrical pattern until it reached a dry gulley (20 m further on) that was connected to the pool.

Fig. 1. A *C. johnstoni* (98 cm SVL) located 75 cm from water in the shade of a dry undercut bank.

3. On 24 August, 1978 at 1320 hr a male *C. johnstoni* (SVL = 98 cm) was located in shade beneath a dry undercut bank, 75 m from a temporary pool (Fig. 1). Tracks indicated that the individual had passed through this pool after leaving a permanent one 20 m further on where a much larger *C. johnstoni* was sighted.

4. On 30 August, 1978, 7 days after the crocodiles in a permanent pool had been caught, marked and released, a set of tracks was discovered directed away from this pool and heading upstream in the river bed. These were followed for 2½ km to the next permanent pool; on the way they entered and left two temporary pools.

5. On 3 September, 1978, two hatchling *C. johnstoni* (approx. 9 months old) were caught amongst dry sticks and flood debris, 25 m and 11 m from the bank of a permanent pool.

It is probably significant that all these observations were made during the dry season, there having been no rain for at least 5 months. The ground over which the animals travelled was parched.

B. MOVEMENT SEQUENCES

The literature suggests that crocodilians progress by three patterns when on land; (1) belly slide, (2) high walk, and (3) gallop (Cott, 1961; Zug, 1974; Webb, 1977). The first two are symmetrical and the other asymmetrical in the terminology of Hildebrand (1966). In a belly slide, a crocodilian propels itself downhill by undulatory movement. The limbs are usually folded back along the sides of the body, though the hind limbs may be used for the initial propulsion. The high walk is characterized by the lifting of the trunk, which is suspended between symmetrically moving limbs; the tail typically swings from side to side with the tip dragging. In a gallop, the hind limbs (and usually the forelimbs as well) move asymmetrically in time, the two sides moving in parallel in what is essentially a series of bounds or hops. The back arches vertically and the tail, which is more or less straight, moves up and down.

1. Belly slide. Our *C. johnstoni* did not practice belly sliding, but the surfaces they traversed were never more than 30° inclined to the horizontal, and were generally hard, dry and rough, consisting of caked sand, rocks and debris with some parts roughened by the dried spoors of water buffalo *(Bubalus bubalis)*. The belly slide actually consists of a walk in which the animal does not lift the trunk off the ground and assists propulsion by body undulation. At low velocities on firmer substrates, the belly slide is perhaps better described as a crawl.

2. High walk. The so-called 'high walk' proved much more diverse than previously described, particular sources of variation being the extent to which the trunk was levered off the ground, the extent to which the limbs were spread laterally, and the velocities attained. Analysis of the slowed down film sequences (particular some in which the animals were travelling towards the camera) documented substantial variability in the lateral and vertical excursions of the hindlimbs. If on slightly rough ground, the pace would differ from stride to stride and often the moving hindlimb would delay its forward travel for 0.05 to 0.10 sec and stabilize the posterior trunk while the anterior column was rotated toward the opposite side. Other variants involved the degree to which the trunk and girdles were bent, to which the hindlimb was rotated medially before firm contact with the ground, and the angles in the vertical plane, at which the limb segments were to each other, and to the trunk. Our records are not sufficient to characterize this variability in detail, though the following categories of high walk were evident:

a. *Classical high walk* — As described by Cott (1961) and Zug (1974), in which velocities are relatively low, the trunk is held high off the ground by the extended limbs and decidely ventriflexed, and the limbs have little lateral spread.

b. *Running* — At higher (and lower) velocities when the trunk is carried lower, so that the hind limbs are not fully extended, they may begin cycling more irregularly and less frequently than the forelimbs. The body, driven by two symmetrically moving hindlimbs, is tilted downward between the driving strokes and upward during them. While the foot position is close to the centerline, the toes are not just placed into and rolled out of contact with the ground. Rather, there is significant slippage between the hindfeet and the ground.

3. Gallop. A run sometimes transforms itself into a gallop, in which both hindfeet hit the ground in parallel within a single stroke. This transformation is signalled by a shift in the angle of the trunk to the ground (becoming 15° to 20°), a lifting of the head (to 30° to the ground) and a folding and unfolding pattern of hindlimb movement (Fig. 2). Often however, the gallop is initiated from a resting position, the first movement being an asymmetrical bound.

The pattern of limb and trunk movements in a typical gallop sequence can be deduced from Fig. 2, in which the frequency of bounds is sufficiently out of phase with the (3.4 f.p.s.) filming rate that each frame represents a different stage of a bound. In a resting position, the femur is more or less horizontal (to the ground in lateral view), the tibia is vertical, and the tail is extended straight, horizontally and in contact with the ground. The initial bound is accomplished by a raising of the anterior body on the front legs, and a rapid unfolding of the hindlimbs such that the femur becomes more or less vertical and tibia horizontal. This unfolding of the limbs raises the acetabulum, an action which appears to be assisted by a marked ventriflexing of the tail (Fig. 2a). The last points of contact with the substrate are the tail tip and hind toes.

As the hindlimbs unfold, the forelimbs simultaneously move forward, first swinging outward, then tilting under the trunk (Figs 2a, b, c); an initial bound essentially terminates when the anteriorly directed forefeet make contact with the substrate. The forelimbs then bend slightly, decreasing the angle between the humeral and radio-ulnar portions, and rotate (Figs 2c, d, e) as the momentum continues to move the trunk forward on them (Figs 2c, d, e).

After the initial unfolding of the hindlimbs (Figs 2a, b), they are refolded and swung outward and anteriorly (Fig. 2c) before being unfolded again (Figs 2d, e). They are fully extended when they make contact with the substrate either next to or anteriorly to the point of contact of the forefeet (Figs 2d, e).

When the hindlimbs are leaving the ground (Figs 2a, b) the thoracolumbar vertebral column is often slightly dorsiflexed, extending the reach of the forelimbs. Following contact between the forelimbs and the substrate (Fig. 2c), the column is always ventriflexed, extending the hindlimb contact anteriorly.

Although the gallop appears more regular than the high walk, irregularities are noted. These are most pronounced within the first few bounds, or when a crocodile grades into or out of a gallop from a run, or when rough or broken terrain is encountered. Sometimes the forefeet make contact with the ground while still pointed posteriorly, in which case the head and thorax hit the substrate, and the animal temporarily collapses. Often the left or the right foreleg leads the other, such

that they are not truly in parallel. Sometimes the forefeet and hindfeet appear to leave the ground at the same instant, giving the impression that the animal is stotting, though this is uncommon. We repeatedly noted series of three to five bounds during which the head was gradually lowered. The next sequence incorporates a marked dorsiflexion of the anterior body. When confronted with either a rise in ground level or an obstruction, animals would often change their angle of attack to the ground by lifting the forequarters; they would then cantilever or propel themselves over the obstruction.

The mean velocities for individual crocodiles are shown on Fig. 3. These data are calculated from filmed (cine or motor drive) sequences of at least three bounds and include crocodiles travelling on a variety of substrates. The animals essentially chose their own path to the water, and the analysed sequences may or may not involve encounters with sand, rough terrain or obstructions. In 78% of sequences there was a definite acceleration after the first bound, though by the third bound, this was usually minimal. For example, the crocodile in Fig. 2 (the first two frames are not included on the figure) has a velocity profile of 14.3, 14.0 (both off sandy bank), 15.0, 16.4, 15.7 and 16.3 km/hr.

Figure 3 shows the relationship between velocity and size. Analysis of variance indicates the correlation is significant at the 0.1% level (Fig. 3; $r^2 = 0.42$). Velocity (V) in km/hr can thus be predicted from snout-vent length (SVL) in cm using the formula: $V = 7.33 + 0.0818\ SVL \pm 1.78$ km/hr (standard error of estimate; Zar, 1974). Relative to body length, the distance covered per bound remains relatively constant (1.3 SVL; Figure 4; $r^2 = 0.86$), the absolute length of each bound increasing with SVL. Bound length (B) in cm can be predicted from SVL in cm using the formula: $B = 1.90 + 1.26\ SVL \pm 8.2$ cm (S.E.E.).

Using the above formulae it can be shown that small crocodiles bound more frequently than larger ones when galloping. For example, a 30 cm SVL *C. johnstoni* could be expected to gallop at 9.8 ± 1.8 km/hr, with a bound length of 39.7 ± 8.2 cm; it would need 6.8 bounds/s. An 80 cm SVL *C. johnstoni* would only need 3.8 bounds/s to be galloping at its velocity of 13.9 ± 1.8 km/hr; bound length = 102.7 ± 8.2 cm.

The higher correlation values for bound length ($r^2 = 0.86$) than velocity ($r^2 = 0.42$) suggest that adjustment to rough terrain involves variations in propulsion forces during contact rather than changes in the distance travelled per bound.

Our observations suggest that the movements grade into each other. However, there is a bimodal distribution of velocities, with the crawl and classical high walk being used for slow locomotion, and the run and gallop for fast locomotion, with occasional intermediates.

DISCUSSION

A. TERRESTRIAL ACTIVITY

Crocodilians emerge from the water for a variety of reasons, though such emergences are usually restricted to the immediate bank area. This implies that the biological roles of emergence can be satisfied there, which would appear the case with basking, skin drying and short-term escape from other crocodiles in the water (aggressive dominant animals or potential predators).

More protracted demands are imposed during nesting activities, when

Fig. 2. *C. johnstoni* (107 cm SVL) galloping along a sand bar. The speed of the motor-drive (3.4 F/s) was sufficiently out of phase with the bounds to demonstrate the sequence of limb movements. From right to left, *a* to *e*.

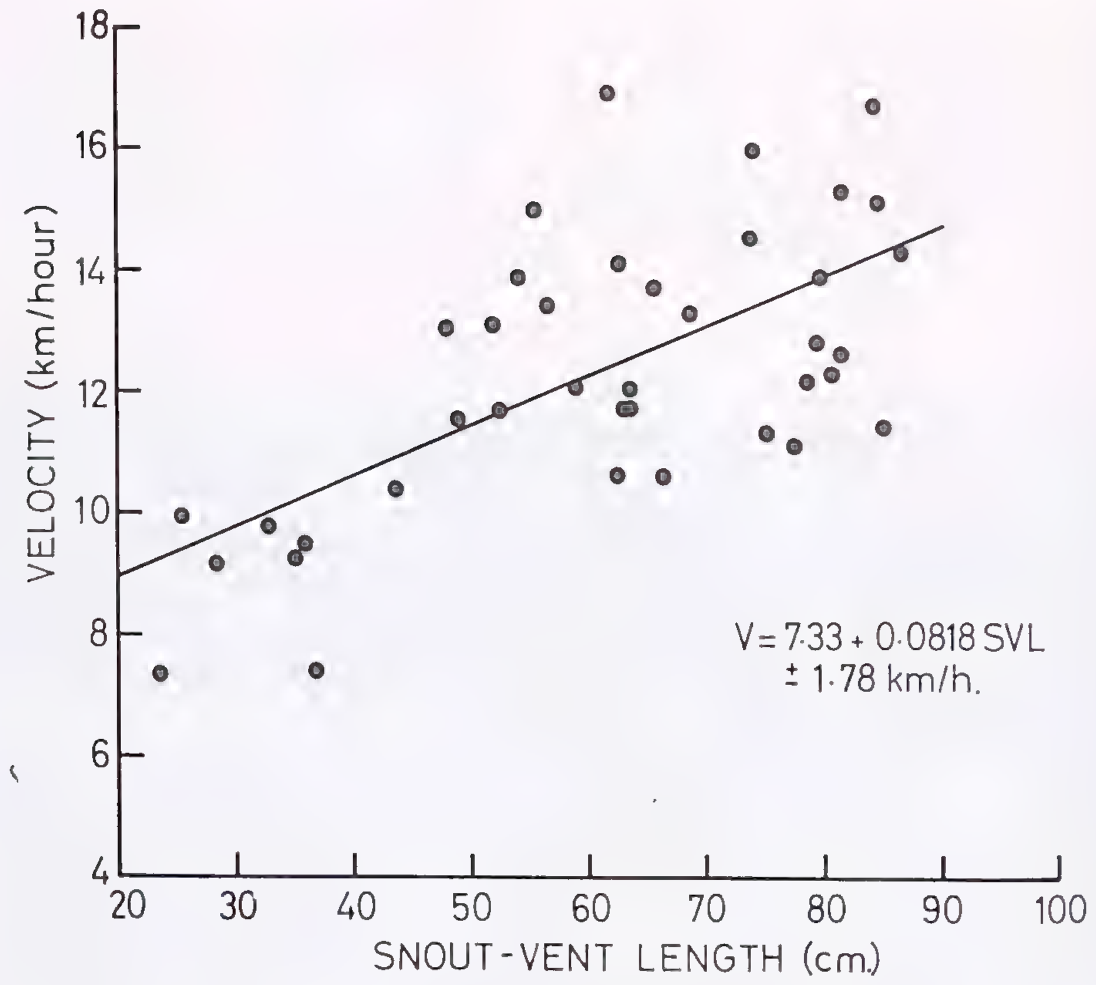

Fig. 3. The relationship between velocity and snout-vent length in galloping *C. johnstoni*.

crocodilians move overland to locate suitable nesting sites, usually within 100 m of permanent water. They continually circle the nest during construction, and may regularly visit the nest during incubation (see for example Cott, 1961; Neill, 1971; Pooley and Gans, 1976; Staton and Dixon, 1977; Webb *et al.*, 1977).

Most crocodilians seem to have the ability to traverse long distances (1 km +) over dry parched country. This permits some species to return to permanent water from areas in which they may have become stranded during floods (e.g. *C. niloticus*; Cott, 1961); however, in others, it is a more regular occurrence and permits them to utilize temporary, seasonally filled bodies of water which may otherwise be unavailable. Such water sources may offer refuges to socially displaced or disturbed individuals, and be a source of concentrated food as water levels recede (see Staton and Dixon, 1975; Gorzula, 1978; pers. observations).

Finally, terrestriality may be associated with foraging. Crocodilians will travel overland to carcasses of dead animals (Pooley and Gans, 1976; pers. observations), and may themselves hunt prey on land, although there are few records of this; *C. porosus* for example has been found on land beneath flying fox colonies, and once approaching a snake moving on an exposed mud bank.

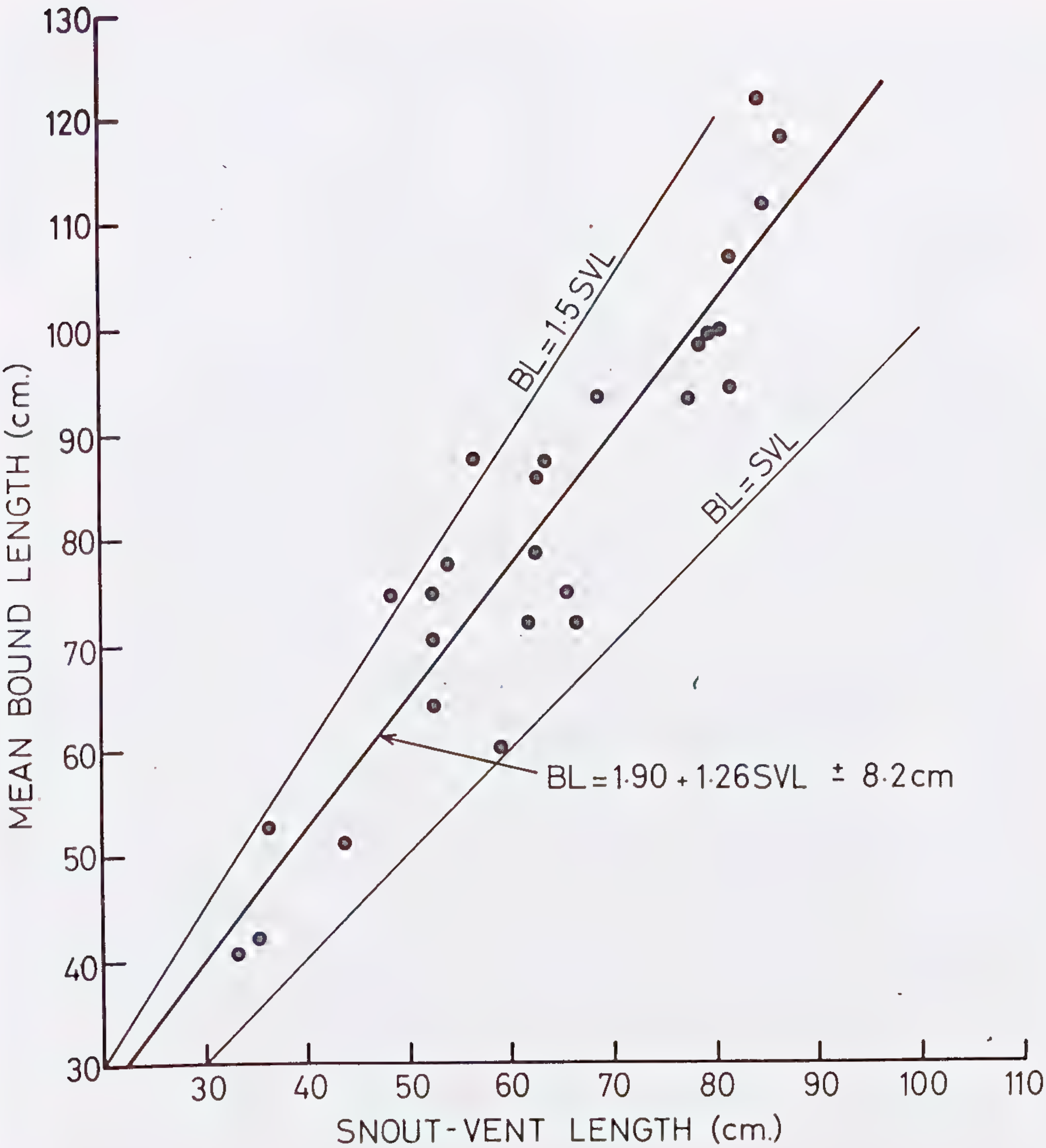

Fig. 4. The relationship between bound length and snout-vent length in galloping *C. johnstoni*.

Most crocodilians that have been studied exhibit terrestriality of the above-mentioned type; however, it appears that few crocodilians show specializations for the utilization of isolated bodies of temporary water in hot dry country. *Caiman c. crocodilus* (Staton and Dixon, 1977; Gorzula, 1978) and possibly *Crocodylus palustris* (Whitaker, pers. comm.) appear to be such exceptions, as is *Crocodylus johnstoni*. Observations indicate that *C. johnstoni* is appreciably more terrestrial than the narrowly sympatric *C. porosus*. In the habitat of the former in Northern Australia there is abundant water during the floods of the wet season (November to May). As the dry season progresses the bodies of water shrink, and overland travel between temporary and/or permanent pools or streams appears common.

Greater terrestriality of the type exhibited by *Crocodylus johnstoni* could be expected to enhance selection for a more extensive motor repertoire, as the animals require several modes of progression. There is a need for a slow steady (perhaps intermittent) walk for travelling overland without the animals being forced onto the glycolytic pathway. The trunk must be held high above the substrate when traversing areas with broken rocks and flood debris, and, more recently, those roughened by buffalo spoor. The high walk meets these requirements. However, predators, now including man, force the crocodiles to cross such terrain rapidly. Speed, coupled with the ability to negotiate obstructions, such as rocks and logs, is then advantageous.

B. GAITS

The fact that we failed to observe the belly slide in *Crocodylus johnstoni* in the McKinlay River probably means only that the animals in question were not tested on suitable substrates. The mud banks occupied by *C. porosus* on the tidal rivers facilitate slippage and the few *C. johnstoni* in such areas do belly slide (personal observations and H. Messel, pers. comm.).

During the classical high walk, the limbs place the feet under or close to the centreline of the body so that the foot remains in contact with the ground during the power stroke, which is fore to aft. However, this rotation of the pelvic girdle and the concomitant undulation of the trunk only occurs when the trunk is lifted fairly high; it is also seen when a crocodile is running. When the trunk is raised only slightly (when crawling in contrast to belly-sliding) the limbs are more straddled and there is little vertebral undulation. Use of either the classical highwalk (slow), the run (fast), or an intergrade, is probably a reflection of the speed required in a particular situation.

The gallop clearly allows increased speed over irregular surfaces. A single stride is slightly longer than the snout-vent length, but varies with the slope and regularity of the terrain (and perhaps the amount of slide after impact). Maximal galloping velocities observed were in the order of four times those of slow high walks, and twice the velocities of a fast high walk (or run). Due to a computational error, the galloping velocities reported by Zug (1974) were in error by an order of magnitude (Zug, pers. comm.). A most important aspect of the gallop however, is that it allows the animals to leap or bound over obstructions such as logs, rocks or small gullies. Such obstacle negotiation often requires an irregularity in a sequence of gallops; the bound length immediately before an obstacle may be reduced, and the subsequent power stroke is delivered in a more vertical direction that allows clearing of the obstacle.

An interesting aspect of rapid locomotion in *C. johnstoni* is the variability associated with it. Thus a crocodile may gallop from a resting position (more usual), or

begin a fast high walk which is gradually transformed into a gallop. Even when galloping, the limb placement can alter, particularly where irregular surfaces are being negotiated. In a number of cases released *C. johnstoni* could not be induced to elicit any rapid escape behaviour (gallop or fast high walk). Such reluctance has not been observed in the wild, and was presumed to reflect the physiological state of the animal. The lactate build up during the capture process could take more than twelve hours to drop to normal levels (compare with Bennett and Dawson, 1977). A further possibility is that in the wild, most long distance terrestrial excursions seem to take place at night (as with *Caiman c. crocodilus;* Staton and Dixon, 1977; Gorzula, 1978), whereas all our animals were released during the day, mostly in bright sunlight.

It would seem important to note that selection on crocodilian motor systems most likely matches the aquatic aspects of their niche. Consequently, adaptations specifically for terrestriality must represent an adaptive compromise between two rather extreme roles. Limbs of crocodilians must have proportions consistent with their use in maintaining the animal in the more usual 'shallow edge of the bank' posture, and must be able to be folded against the trunk during the undulating movements associated with swimming; they are rather short for an effective gallop.

Finally, there are a number of aspects of crocodilian galloping which are unclear. Is the capacity to gallop a recent development, or an ancestral one? It may well be that the majority of extant crocodilians can gallop if placed in the type of environment in which *C. johnstoni* are found in the McKinlay River, although *Caiman crocodilus* and *Crocodylus palustris* appear to live in similar habitats and have not been observed galloping (Dixon and Whitaker, pers. comm.). Thousands of observations of locomotion of *C. porosus* in the tidal areas of Northern Australia have revealed only a few which galloped; Zug (1974) filmed *C. porosus* galloping in New Guinea. Fossil evidence has been used to suggest that galloping was extremely well developed in some crocodilians. Thus, Walker (1970) concluded from limb structure that the Upper Jurassic *Hallopus victor* had a "hare-like bounding gallop" as its most probable form of fast locomotion.

Unfortunately, there is a scarcity of information on locomotory patterns of extant crocodilians in the wild, and it is thus not possible to be certain that the regular use of galloping by *Crocodylus johnstoni* is as unique as it would appear. However, the results do indicate the utility of and need for further research on crocodilian locomotory behaviour. Then perhaps, it will be possible to determine whether or not there are structural correlates associated with galloping in extant crocodilians.

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DESCRIPTIONS OF TYPES AND OTHER ALCYONACEAN MATERIAL (COELENTERATA: OCTOCORALLIA) IN THE AUSTRALIAN MUSEUM, SYDNEY

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SUMMARY

Six types of alcyonaceans, previously described by Whitelegge (1897) and Thomson & Mackinnon (1911), have been re-examined. Two new species of octocorals recently collected by Ms Helen K. Larson and a known species collected by Mr Neville Coleman are also described.

INTRODUCTION

During March and April 1977 the authors worked on octocorals in the Roche Research Institute of Marine Pharmacology at Dee Why, Sydney, Australia. During his stay in Australia the senior author (J.V.) was told that Whitelegge's (1897) and Thomson & Mackinnon's type specimens were kept in the Australian Museum, Sydney. He knew there were taxonomic problems with the type collection deserving investigation, especially with the species *Sinularia ("Lobophytum") densa.*

With the assistance of Dr J.K. Lowry (Australian Museum) we were able to examine all six types of alcyonaceans. We found that in many respects Whitelegge's and Thomson & Mackinnon's descriptions are correct, but in other respects our re-examination led to surprising results: *Lobophytum hedleyi* Whitelegge = *L. crassum* Von Marenzeller; *Sinularia ("Lobophytum") densa* has foliaceous clubs, which were not recorded by Whitelegge, with all the unpleasant consequences of this; *Spongodes pallida* Whitelegge must be transferred to the genus *Scleronephthya.* In some cases the smallness of the specimens and the paucity of the material prevented us from making more detailed investigations.

At the request of Ms Helen K. Larson, Technical Officer, Australian Museum, the senior author investigated a number of octocorals collected by her near Lizard Island, Great Barrier Reef. In her collection he found two new species, viz. *Sinularia larsonae* sp.n and *Nephthea legiopolypa* sp.n. They are kept in the Museum mentioned, and are described below.

Finally, Mr Neville Coleman sent J.V. samples of octocorals from Australian waters. Among them was a specimen of *Dendronephthya (Morchellana) australis* Kükenthal, 1905. It is redescribed here.

P.A. made the photographs of Whitelegge's and Thomson & Mackinnon's specimens, while Mr G.J. Vrijmoeth made the photographs of other colonies. J.V. made the drawings for the text-figures.

Records of the Australian Museum, **Vol. 34 No. 15,** 619-647, Figs 1-9, Pls 1-8.

Australian Museum register numbers are preceded by the abbreviation AM. One of Coleman's specimens is kept in the Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands; the register number is preceded by the abbreviation RMNH.

LIST OF SPECIES EXAMINED

Order Alcyonacea Lamouroux, 1816
Family Alcyoniidae Lamouroux, 1812
1. *Alcyonium etheridgei* Thomson & Mackinnon, 1911
2. *Lobophytum crassum* Von Marenzeller, 1886 = *L. hedleyi* Whitelegge, 1897
3. *Sinularia densa* (Whitelegge, 1897)
4. *Sinularia larsonae* sp. nov.

Family Nephtheidae Gray, 1862
5. *Dendronephthya (Morchellana) australis* Kükenthal, 1905
6. *Dendronephthya (Morchellana) waitei* Thomson & Mackinnon, 1911
7. *Nephthea legiopolypa* sp. nov.
8. *Scleronephthya pallida* (Whitelegge, 1897)

Family Nidaliidae Gray, 1869
9. *Siphonogorgia macrospina* Whitelegge, 1897

TAXONOMIC ACCOUNT

Alcyonium etheridgei Thomson & Mackinnon, 1911
Fig. 1, Pl. 1A-C

Alcyonium etheridgei Thomson & Mackinnon, 1911:666-668, Pl. 61 figs 2, 3, Pl. 62 fig. 3, Pl. 67, fig. 4, Pl. 69; Verseveldt, 1977b:177-179, Figs 2, 3, 39b.

MATERIAL: Manning Bight, depth 40 m (22 fathoms). AM G12170, holotype; AM G12171-G12180, paratypes.

DESCRIPTION OF THE HOLOTYPE: The colony is 75 mm high, the maximum width is 65 mm (Pl. 1A). The main stem is 32 to 35 mm wide. It gives off two branches, 17 and 21 mm wide, each bearing short, thick lobes, rounded or fingerlike, 4 to 15 mm wide and up to 30 mm long. The bottom 10 mm of the base of the stem are free from polyps. All of the anthocodiae are fully retracted, most of them into dome-shaped calyces, but many hardly project at all. The polyp heads are armoured with eight rows of longitudinally arranged, thin, spiny needles, up to 0.40 mm long; see Verseveldt, 1977b, Fig. 2c-e. The armature is as figured in Verseveldt's Fig. 2b, but with fewer sclerites per row.

In the surface layer of the branches and lobes there are spiny or warty spheres, ovals and dumb-bells, 0.07 to 0.16 mm long (Fig. 1a-e). Occasional spindles and clubs also occur, especially in the summits of the lobes; they are up to 0.33 mm long (Fig. 1f-h). The tips of the eight teeth of the calyces mainly contain clubs.

In the surface layer of the stem the majority of the sclerites are dumb-bells with a distinct waist; length: 0.07 to 0.18 mm (Fig. 1i).

The interiors of the branches and the lobes have very few, scattered sclerites: warty-ended dumb-bells, 0.07 to 0.16 mm long (a few are 0.21 mm long), all with a distinct waist. In the coenenchyme of the base of the stem two layers can be distinguished:

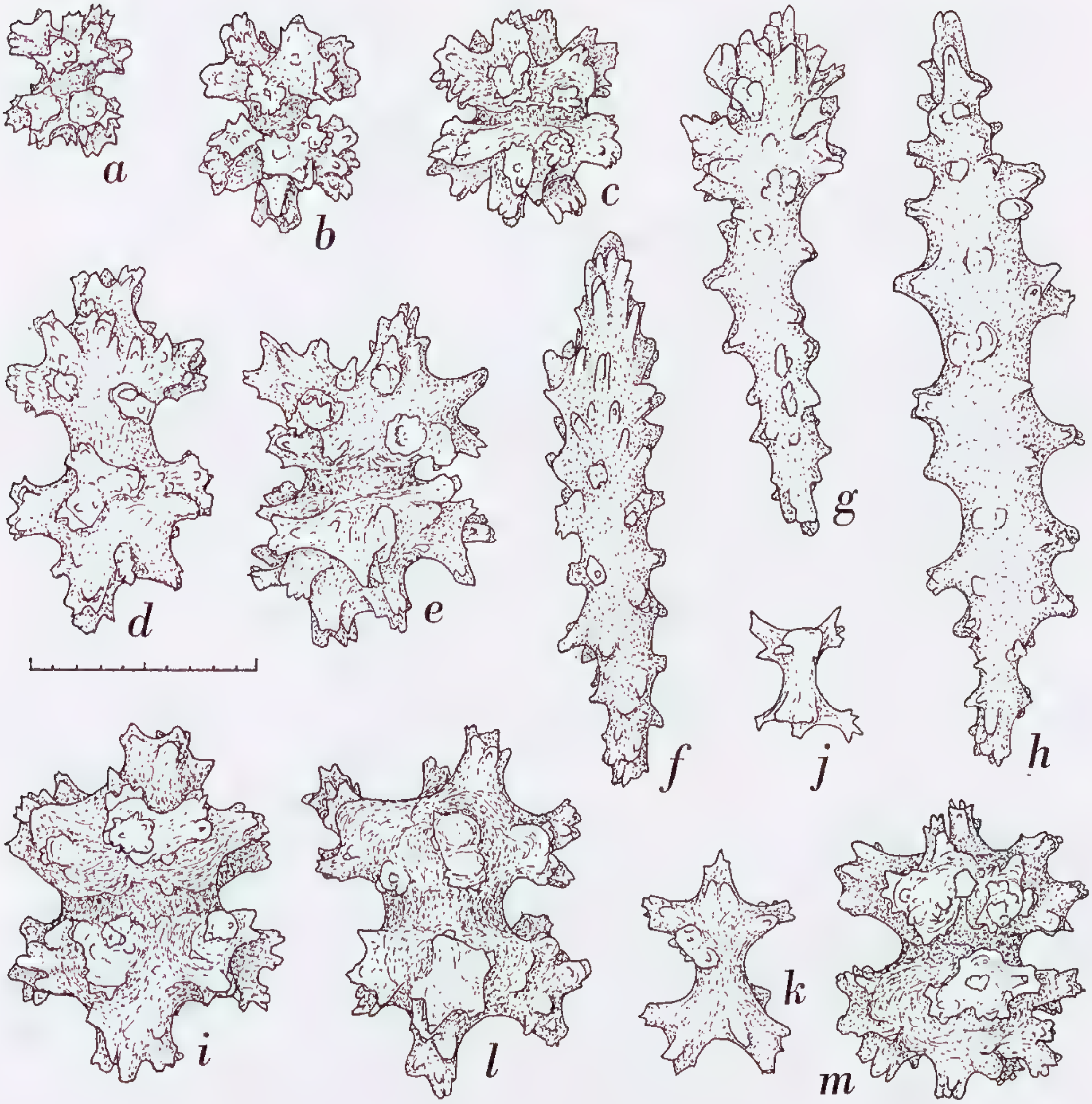

Fig. 1. *Alcyonium etheridgei* Thomson & Mackinnon, holotype, AM G12170. **a-h,** sclerites from surface layer of a lobe; **i,** sclerite from surface layer of the stem; **j-m,** sclerites from coenenchyme of the stem. (Scale line = 0.1 mm)

1. An outer layer, 3 to 4 mm thick, densely packed with sclerites all showing a distinct waist. Some of them are warty-ended dumb-bells, 0.09 to 0.18 mm long; some are as wide as they are long (Fig. 1l,m), others are smaller, smooth, with antlerlike ends ('antler-capstans'), 0.04 to 0.09 mm long (Fig. 1j,k).

2. The inner layers of the coenenchyme have sclerites of the following types: (a) a few warty spheres and ovals, up to 0.18 mm long, (b) warty-ended dumb-bells, 0.09 to 0.18 mm long, and (c) 'antler-capstans', 0.04 to 0.09 mm long.

VARIABILITY: In some respects the paratypes G12171 to G12180 show some variability:

The amount of the stem base free of polyps is quite variable, being at least 10 mm in all but one colony and up to 30 mm in G12177.

Some paratypes have expanded polyps (Pl. 1B). The quantity of spindles making up the longitudinal rows in the anthocodiae is quite variable. Whereas in the holotype and G12173 a row is about 5 to 7 needles wide and neatly arranged, intermediates are found leading to G12180, where the row may be twenty needles wide at the base, and they are often very irregularly arranged.

In the spiculation in other parts of the colonies, we also found variability. The holotype G12170 described above appears to represent one end of the spectrum with paratype G12180 forming the other.

In the calyx the proportion and size of clubs and spindles varies. The holotype and most of the paratypes display only a few clubs and spindles in the vicinity of the eight calycal teeth; their length is 0.19 to 0.31 mm. In G12179 and especially in G12180, virtually the whole of the calyx is composed of spindles and clubs, which extend on to the surface of the colony and often, particularly on the lobes, occupy the whole space between neighbouring polyps. The lengths of these sclerites are far greater, 0.19 to 0.45 mm. The occurrence of spindles and clubs in the surface layer of the colony varies from rare to frequent. In the interior of the lobes there are variations in the occurrence and type of the sclerites. In some paratypes the dumb-bells are few and scattered, in others entirely absent. In G12180, although rare, some spindles and clubs are present with the dumb-bells.

A notable item in the interior of the stem is the erratic occurrence of the small 'antler-capstans'. In the holotype they are present in large numbers, in some paratypes (e.g. G12180) they are entirely absent.

REMARKS: At the end of their description Thomson & Mackinnon (1911:667) say that in many respects this species comes very near to Hickson's *Alcyonium purpureum* (Hickson, 1904:215-217, Pl. 7 fig. 1, Pl. 9 fig. 18).

The senior author (J.V.) has had the opportunity to investigate a co-type of this species in the British Museum (Natural History), register number 1962.7.20.19. (This specimen is rather like the colony represented by Hickson, Pl. 7 fig. 1; if they are really the same colony, the enlargement of Hickson's drawing is × 1.2 and not natural size as stated by him.) It appeared, however, that the specimen described by Hickson was not one colony, but a number of small, more or less spherical colonies, 15 mm high, oval in shape when seen from above; the largest diameter was 20 mm. All these colonies are attached to a tunicate test: a relatively high, dome-shaped, hollow, white, cartilaginous substratum, a few mm thick. So Hickson's 'lobes' are really colonies. Consequently there is no question of any relation to *A. etheridgei*.

Lobophytum crassum Von Marenzeller, 1886

Fig. 2, Pls 2-4

Lobophytum crassum Von Marenzeller, 1886: 363-364, Pl. 9 fig. 8a-c (for synonymy of *L. crassum* see Tixier-Durivault, 1958: 173-174).

Lobophytum hedleyi Whitelegge, 1897: 216-217, Pl. 10 figs. 2a-h; Thomson & Dean, 1931: 68; Verseveldt, 1960: 218.

? *Lobophytum hedleyi*, Pratt, 1905: 252-253; Roule, 1908: 176-177; Lüttschwager, 1915: 32; Moser, 1919: 287-288; Roxas, 1933: 366.

non *Lobophytum hedleyi*, Cohn, 1908: 223-224; Tixier-Durivault, 1956: 541; Tixier-Durivault, 1958: 163-164, Figs. 180, 194, 195; Tixier-Durivault, 1966: 92-96, Figs. 82-84.

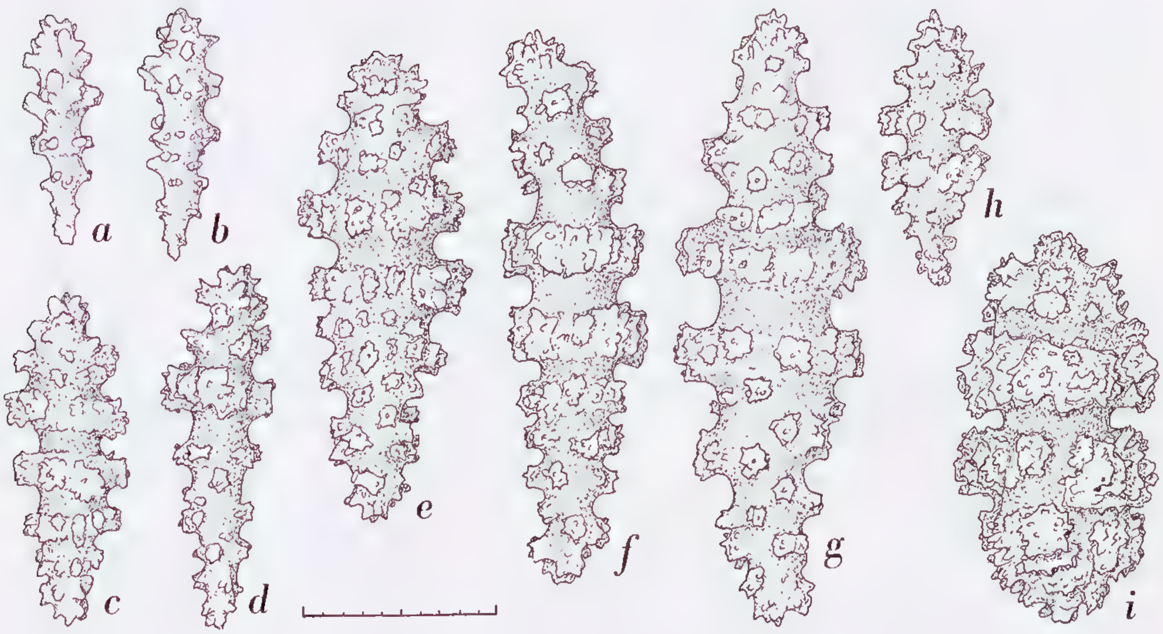

Fig. 2. *Lobophytum crassum* Von Marenzeller (=*L hedleyi* Whitelegge). Whitelegge's type specimen, AM G1537. **a-e,** clubs and spindles from surface layer of a lobe; **f, g,** spindles from interior of a lobe; **h,** sclerite from surface layer of the sterile stalk; **i,** sclerite from coenenchyme of the stalk. (Scale line = 0.1 mm)

MATERIAL: Funafuti Atoll, Ellice Is.; AM G1537, three colonies, Whitelegge's type specimens.

PRELIMINARY NOTE: We hold the view that *L. crassum* Von Marenzeller and *L. hedleyi* Whitelegge are one and the same species. In the following we first give a description of Whitelegge's type specimens and then make some remarks on *L. crasssum*.

DESCRIPTION OF THE LARGER TYPE SPECIMEN OF *L. HEDLEYI:* Whitelegge (1897, Pl. 10 fig. 2a) gave a good drawing of this colony. Our Pl. 2 shows the same colony seen from above and from the side. Additional remarks concerning the size and the shape of the lobes are superfluous. On the distal parts of the lobes the irregularly disposed autozooids are 0.70 to 1.50 mm apart; there are one or two siphonozooids between them. Towards the base of the lobes the distance of the autozooids increases, and so does the number of the siphonozooids: four to eight siphonozooids between two autozooids.

The surface layer of the lobes has clubs, 0.12 to 0.20 mm long, with weakly developed heads and usually two distinct median girdles of warts (Fig. 2a-d). Sclerites like the one represented by Whitelegge, Pl. 10 fig. 2g also occur; their length is 0.15 to 0.23 mm.

In the interior of the lobes lie spindles, 0.22 to 0.35 mm long, with two median girdles of warts separated from each other by a distinct waist (Fig. 2f,g). Besides these two girdles a few more may be present. The sclerite Fig. 2e is a transitional form between a clavate sclerite from the surface layer and a coenenchymal sclerite.

The clubs in the surface layer of the sterile stalk are slightly shorter and wider; the length varies from 0.12 to 0.17 mm (Fig. 2h). The coenenchymal sclerites in the stalk are of two

types: (a) ovals or barrels, 0.18 to 0.22 mm long, with two distinct median girdles of coarse warts and two terminal clusters of warts (sometimes these clusters look like a girdle of smaller warts with a terminal one) (Fig. 2i), and (b) spindles resembling those in the coenenchyme of the lobes; they are 0.23 to 0.32 mm long.

VARIABILITY: One of the other colonies referred to as *L. hedleyi* by Whitelegge (1897) has a total height of 40 to 45 mm and a maximum width of 45 mm. The third colony (Pl. 3) is a bigger one. In these specimens most of the lobes are fingerlike, just as in the specimen described above, but the autozooids are more densely placed.

REMARKS ON PREVIOUS IDENTIFICATIONS: Pratt's determination (1905) may be right, that of Roule (1908) is doubtful, that of Cohn (1908) is wrong. Lüttschwager's (1915) and Moser's (1919) identifications are presumably right, but Lüttschwager overlooked the difference between spines (*Dornen*) and warts (*Warzen*). Moser did not mention the clubs. Roxas' description (1933) is essentially the same as Moser's.

Tixier-Durivault's description (1958) cannot be right, as is shown in the following table (length of sclerites in mm).

TABLE 1: Features of *'Lobophytum crassum'* specimens.

Tixier-Durivault, 1958	Whitelegge, 1897	Own observations on Whitelegge's type specimen
1. **Colony** fleshy	stem rigid, harsh to touch	stem rigid, harsh to the touch; lobes firm but flexible
2. **Sclerites:**		
a in surface lobe: clubs (and spiny rods) up to 0.14 mm	see below at *c*	clubs 0.12–0.20 mm
b in interior lobe: needles 0.24–0.32 mm, processes irregularly placed	spindles 0.15–0.30 mm, tubercles in whorls	spindles 0.22–0.35 mm, tubercles in whorls, especially the median ones
c in surface stalk: clear cylinders 0.11–0.15 mm	clubs 0.12–0.15 mm	clubs 0.12–0.17 mm
d in interior stalk: small barrels 0.18 mm	subcylindrical 0.15–0.20 mm	ovals, barrels 0.18–0.22 mm
with 4 rows of irregularly placed tubercles	4-6 whorls of tubercles	2 distinct median whorls of tubercles and 2 less distinct whorls
tubercles not very voluminous	spiny tubercles	compound tubercles
spindles not recorded	?	spindles present, 0.23–0.32 mm

TABLE 1 continued

Tixier-Durivault, 1958	Whitelegge, 1897	Own observations on Whitelegge's type specimen
3. **Autozooids:**		
distance 0.3–0.8 mm	wide intervals, on margins and summits of lobes 1–2 mm or even less apart	intervals 0.75–1.50 mm on summits of lobes
4. **Siphonozooids:**		
1, 2 or 3 between two autozooids	as many as 12, on the margins fewer	tip lobes 1–3, base lobes 4–8

Remarks on *L. crassum* Von Marenzeller, 1886: In her description of *L.crassum* Tixier-Durivault (1958: 174) states that she received a photograph of Von Marenzeller's type specimen. She kindly allowed us to make a copy of this photograph and also of another photograph of the same colony, side-view (Pl. 4; see also Tixier-Durivault, 1958, Fig. 191).

A comparison of the photographs of *L. hedleyi* and of *L. crassum* shows that the lobes have the same dimensions and fingerlike shape; a distinct difference cannot be established.

Von Marenzeller (1886) says very little about the distribution of the autozooids and the siphonozooids in *L. crassum*; the number of siphonozooids between the autozooids is not mentioned at all. However, on the tips of some lobes in Pl. 4 the autozooids are visible; their mutual distances are the same as in *L. hedleyi*.

The spiculation of both species is also the same. Tixier-Durivault investigated the sclerites of Von Marenzeller's type specimen of *L. crassum*. The coenenchymal sclerites in the sterile stalk are 0.15 to 0.20 mm long, in Whitelegge's type of *L. hedleyi* 0.18 to 0.22 mm. In both species spindles are scarce in the sterile stalk. In the lobes the spindle-shaped spicules predominate. According to Von Marenzeller the length in *L. crassum* is 0.25 to 0.32 mm (Tixier-Durivault, 1958: 176, has 0.22 to 0.29 mm); the width is 0.07 (to 0.08) mm. In *L. hedleyi* the length varies from 0.22 to 0.35 mm, the width from 0.08 to 0.10 mm. The shape and the distribution of the tubercles (with median girdles) is the same. The clubs in the surface layers of lobes and stalks do not show any difference either.

CONCLUSION: Thomson & Dean (1931: 67) stated that one of the colonies of *L. crassum* investigated by these authors 'shows some points of resemblance, especially in its mode of growth and spicules, to Whitelegge's *L. hedleyi*; but it seems still closer to the variable *L. crassum*. Whatever view be taken as to the separateness of the species, *L. hedleyi* and *L. crassum* must be close together.'

The present authors go further: we are of the opinion that there is no essential difference between the two species, and that the junior name *hedleyi* must therefore be abandoned.

Sinularia densa (Whitelegge, 1897)
Fig. 3, Pl. 5A

Lobophytum densum Whitelegge, 1897: 219-220, Pl. 11 figs. 4a-h.
? *Lobophytum densum*, Hickson & Hiles, 1900: 505-506.

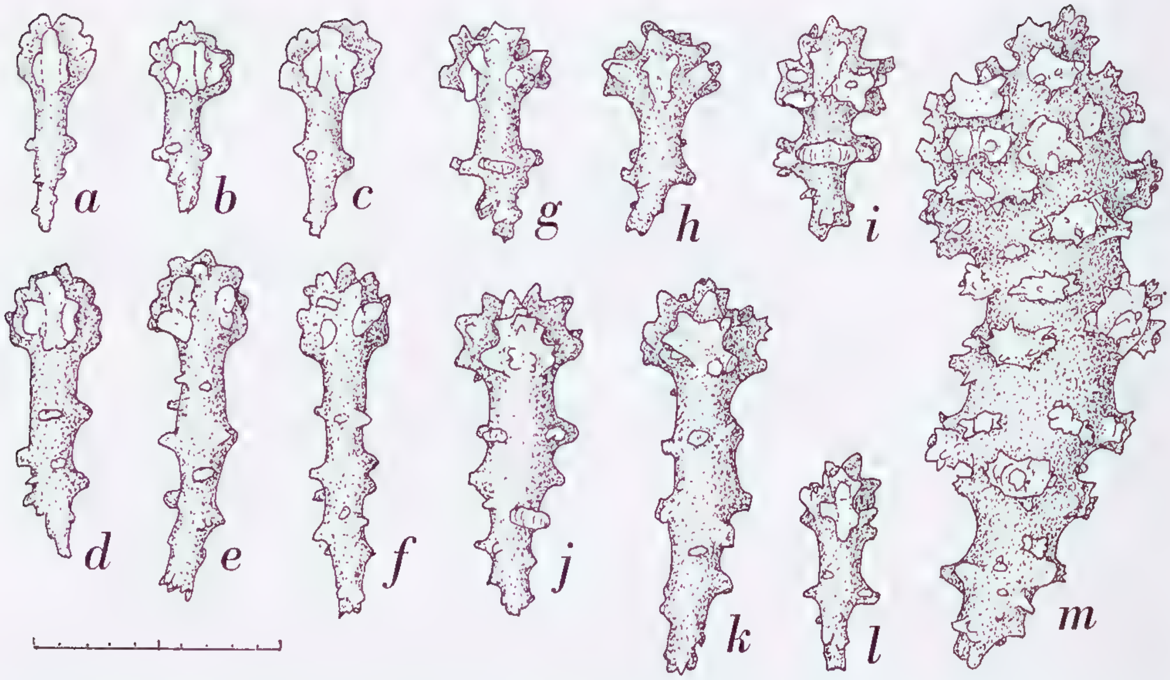

Fig. 3. *Sinularia densa* (Whitelegge), type specimen, AM G1541, **a-f,** clubs from surface layer of a lobe; **g-m,** sclerites from surface layer of the sterile stalk. (Scale line = 0.1 mm)

? *Sclerophytum densum,* Pratt, 1903: 521, Pl. 29 fig. 18, Pl. 30 figs. 20-22; Pratt, 1905: 256; Thomson & Simpson, 1909: 6; Thomson & Mackinnon, 1910: 177; Cary, 1931, Pl. 4 figs. 12, 13.

Sclerophytum densum, Thomson & McQueen, 1907: 55 (perhaps right).

? *Sinularia densa*, Lüttschwager, 1915: 11.

non *Sinularia densa,* Kolonko, 1926: 314-315; Tixier-Durivault, 1945: 59; Tixier-Durivault, 1951: 38-41, Figs. 39, 40, 45-48; Verseveldt, 1960: 233-235, Pl. 7 fig. 4; Tixier-Durivault, 1966: 182-185, Figs. 175-177; Tixier-Durivault, 1970: 149.

Sinularia brongersmai, Verseveldt, 1972: 460-463, Figs. 2, 3, Pl. 1 fig. 2; Verseveldt, 1977a: 20-21, Fig. 14, Pl. 6 fig. 2.

MATERIAL: Funafuti Atoll, Ellice Is. AM G1541, one colony, Whitelegge's type specimen.

NOTES ON TYPE SPECIMEN AM G1541: The colony is hard. The lobes have been correctly described by Whitelegge (1897). The description of the sclerites, however, deserves important additions.

The surface layer of the lobes contains numerous clubs, 0.08 to 0.16 mm long, the smaller ones with distinct foliaceous heads; the handles bear blunt spines; their number depends on the length of the handle (Fig. 3a-f). In the sterile stalk the surface layer has also numerous clubs; they are of the same length, but they are wider, the heads are coarser, and have more wartlike prominences (Fig. 3g-l). Big clubs with spiny warts (Fig. 3m) may be regarded as transitional forms to coenenchymal sclerites.

In the coenenchyme of lobes and sterile stalk lie pointed spindles, in the lobes up to 4 mm long, in the stalk up to 2.50 mm. In a few cases they are forked at one end. They are covered with high, strongly crenellated warts, usually 0.07 to 0.08 mm in diameter (processes included; the diameter of warts should always be measured in a direction parallel to the longitudinal axis of the sclerite, for in a transverse direction the warts are often strongly

developed or fused). The warts on the spindles from the lobes are usually regularly arranged in transverse rows; those on the spicules from the stalk are often irregularly placed. The coenenchyme of the stalk also contains numerous small spindles, 0.15 to 0.40 mm long; they bear some spines. Between these and the stout coenenchymal spicules there are transitional forms.

REMARKS: Whitelegge's incomplete description of the sclerites must be the cause of so many subsequent incorrect or dubious identifications and descriptions (see the synonymy above). The more or less deceptive drawing of the club with its spiny head in Whitelegge's Pl. 11 fig. 4h, and especially the failure to mention the occurrence of the small foliaceous clubs in the lobes must have confused many investigators.

In 1972 J.V. described the new species *S. brongersmai*. A comparison of this species with *S. densa* described above shows that the differences are of very little importance. We are therefore of the opinion that the junior name *brongersmai* must be abandoned.

Sinularia larsonae sp. nov.

Fig. 4, Pl. 5C

MATERIAL: Lizard Is., Great Barrier Reef, lagoon, SE of Palfrey Is., depth 4–8 m, 2 November 1975. H.K. Larson no. LZ 75-4, AM G14800; one colony, holotype.

DESCRIPTION: The basal part of the sterile stalk has been cut off slantingly. The remaining part of the colony has a total height of 65 mm. The maximum spread of the capitulum is 75 mm (Pl. 5C). The sterile part is 30 to 35 mm wide. It imperceptibly passes into the polyp-bearing capitulum. The latter consists of some thick branches, which in their turn bear some side-branches. These are cylindrical, sometimes slightly curved, 4 to 7 mm wide and usually 8 to 12 mm long; a few are up to 20 mm long. In some cases these branches are indented at the top. The whole colony is hard and stiff.

The polyps are completely retracted, leaving shallow pits; at their bottom are eight-rayed openings. The centres are 1.00 to 1.50 mm apart; in the distal parts of the branches they are less distant.

The surface layer of the branches and of the sterile stalk has clubs 0.10 to 0.24 mm long (Fig. 4a-h). The heads consist of some blunt-ended processes or simple warts; in many cases a central wart is present. The handles are straight or slightly curved rods, with a few low cones.

In the coenenchyme there are usually curved spindles, in the branches up to 5 or 6 mm long (Fig. 4i, j), in the sterile stalk right up to 10 mm long (Fig. 4k-o). Many of them have a median constriction; a few are bifurcated at one end. The warts are small to medium-sized, about 0.05 mm in diameter. They may be in transverse rows or irregularly distributed; they stand close together or wider apart; sometimes the processes are only low cones. All these differences can be found on one and the same spicule.

Colour: In alcohol the colour is brown.

REMARKS: The species is characterized by the tree-like shape of the colony, by the long, slender, nearly smooth handles of the clubs in the surface layer, and, last but not least, by the extraordinary long coenenchymal spicules.

The species is named after Ms Helen K. Larson, collector of the specimen.

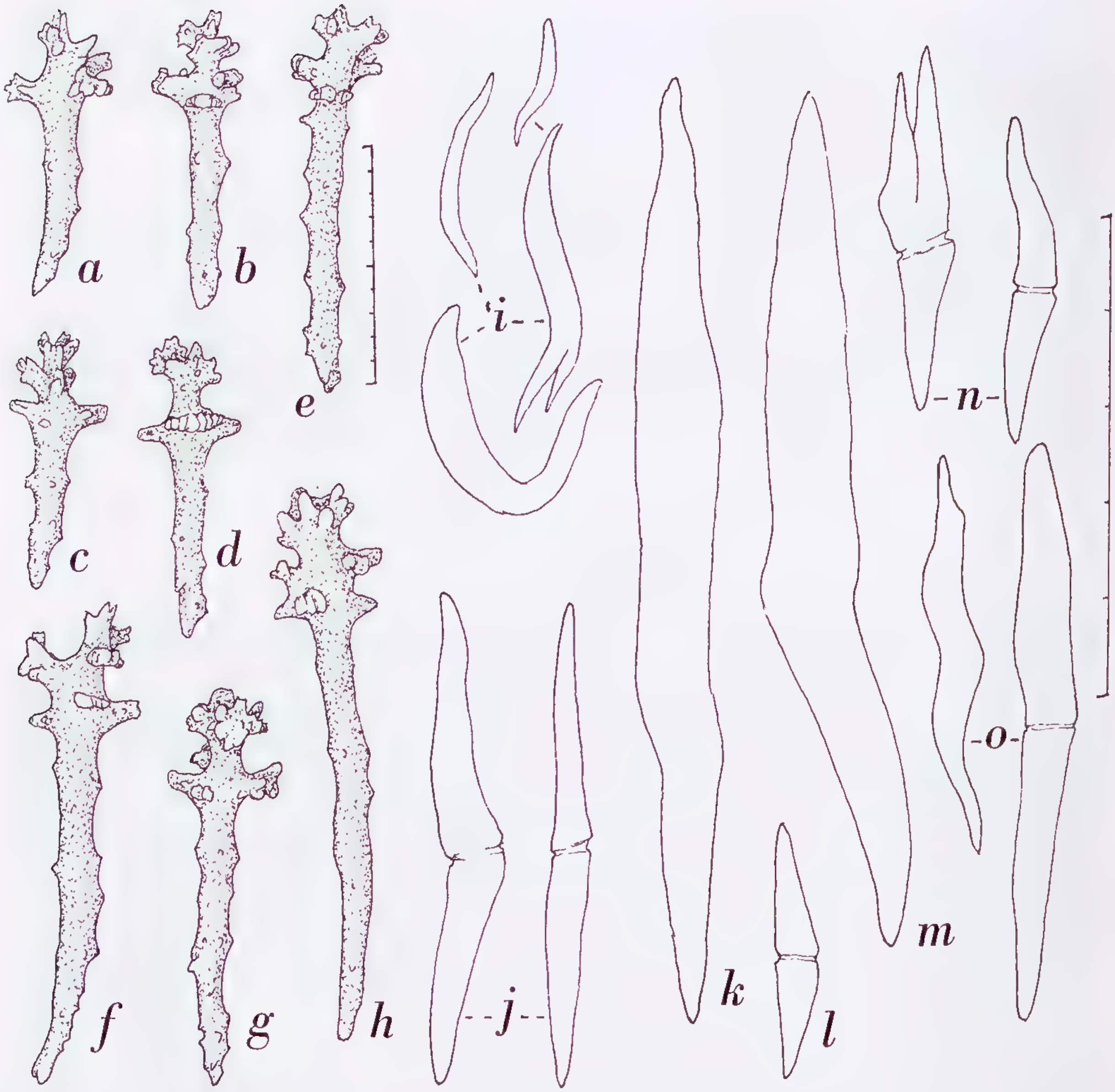

Fig. 4. *Sinularia larsonae* sp. nov., holotype, AM G14800. **a-h**, sclerites from surface layer of a lobe; **i-j**, sclerites from interior of a lobe; **k-o**, sclerites from interior of the sterile stalk. (Enlargement of **a-h** indicated by 0.1 mm scale at **e**; that of **i-o** by 5 mm scale to the right of **n-o**.)

Dendronephthya (Morchellana) australis Kükenthal, 1905
Fig. 5, Pl. 5B

Dendronephthya australis Kükenthal, 1905: 631-632, Fig. F[1], Pl. 29 fig. 32.
Morchellana australis, Tixier-Durivault & Prevorsek, 1962: 17-21, Figs. 2-4.

MATERIAL: Fly Point, Port Stephens, N.S.W., Australia, depth 18 m, 6 December 1975. N. Coleman no. 274, RMNH Coel. no. 12299, one colony.

DESCRIPTION OF COLONY RMNH COEL. NO. 12299. The flabby colony is 55 mm high (Pl. 5B). The sterile stalk, 20 to 25 mm long, is flattened laterally and furrowed longitudinally.

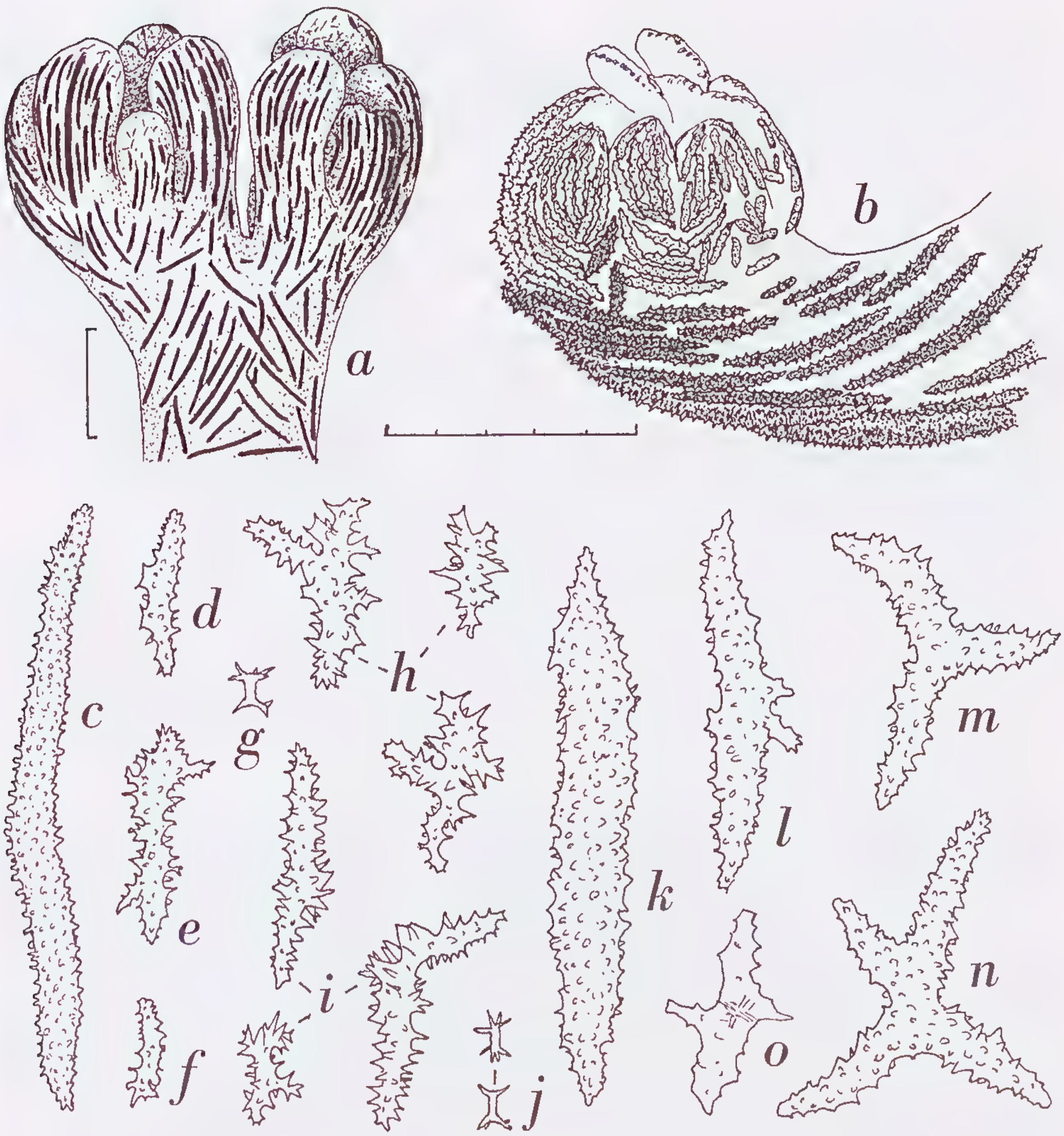

Fig. 5. *Dendronephthya (Morchellana) australis* Kükenthal, RMNH Coel. no. 12299. **a**, small 'lobe'; **b**, polyp; **c-f**, sclerites from surface layer of the stem; **g-j**, sclerites from surface layer of the sterile stalk; **k-o**, sclerites from coenenchyme of the stalk. (Enlargement of **a** indicated by 1 mm scale adjacent; that of **b-o** by 0.5 mm scale at **b**.)

Its basal half is covered with grey mud. The polyparium, too, is flattened laterally. It is widest distally: 23 mm. The sterile stalk passes into the stem, which distally divides into a few branches. In this part of the colony the groups of polyps are numerous and densely placed, whereas proximally only small groups are found, which stand further apart. There are no foliaceous branches.

At first sight these groups of polyps resemble the lobes of *Nephthea,* but on closer investigation it appears that the polyps are not regularly distributed all over the 'lobe' as is the case with *Nephthea,* but arranged in small, round, nearly unstalked groups of about six polyps, which groups or umbels are united into larger 'lobes'. Fig. 5a represents a small 'lobe' consisting of a short, thick twig with only two umbels. Proximally the 'lobes' are small, distally they are larger and composed of numerous, crowded umbels. Besides, on one side of the flat colony the 'lobes' are more numerous than on the other side.

The spherical anthocodiae, about 0.70 mm wide, form right angles with their short stalks, 0.10 to 0.40 mm long (Fig. 5b). Their wall is densely filled with spiny spindles. Those on the asulcal (dorsal) side are largest, averaging 0.30 mm long; on the lateral sides they are 0.12 to 0.20 mm long, on the sulcal (ventral) side 0.07 to 0.13 mm. In many cases they show an arrangement *en chevron,* with six to eight spicules in a row. The supporting bundle is weak. It consists of some spiny spindles, up to 1 mm long. They are red in colour, as are the basalmost anthocodial sclerites; the other anthocodial sclerites are colourless. In the drawing Fig. 5b the red spicules are more darkly spotted. In the tentacles, which may be extended, there are minute, strongly toothed scales, 0.045 to 0.065 mm long.

Anthocodial grade and formula: II = (6-8)p + 0 Cr. +weak S.B.

The sclerites in the surface layer of the stem are of two types: (1) curved rods, up to 1.30 mm long and 0.12 mm wide (prominences included; 0.07 mm, without prominences), and densely covered with spines (Fig. 5c), and (2) shorter spindles, 0.20 to 0.50 mm long, with higher, sharp spines (Fig. 5d-f). Many of them have long, pointed processes. In the surface layer of the sterile stalk the sclerites, about 0.40 to 0.50 mm long, are irregularly shaped and very spiny (Fig. 5h, i). In addition to these there are small sclerites, 0.06 to 0.08 mm in length or in diameter; many of these are dumb-bells with heads formed by a few spines (Fig. 5g, j).

The coenenchyme of the sterile stalk contains spindles and derivative forms of these, tri- and quadriradiates, etc. The length is up to 1.20 mm; their surface is covered with high cones (Fig. 5k-n). A few flat sclerites also occur (Fig. 5o).

Colour: In alcohol the sterile stalk and the basal part of the stem are dirty-white. Distally the sclerites become increasingly redder, the twigs and supporting bundles having dark-red spicules. The anthocodiae are white.

REMARKS: As we said above, the specimen looks like a *Nephthea* species with rounded lobes. These 'lobes', however, usually consist of a number of smaller groups, the umbels, but these umbels stand so close that they can hardly be called umbels.

In addition to this, the species is characterized by the armature of the polyps and by the shape of the sclerites in the surface layer of stem and stalk.

GEOGRAPHICAL DISTRIBUTION. The species has previously been recorded from Port Jackson and Port Hacking, both in the neighbourhood of Sydney, Australia, as is Port Stephens, the locality of the specimen described above.

Dendronephthya (Morchellana) waitei Thomson & Mackinnon, 1911

Figs. 6, 7, Pl. 6

Dendronephthya waitei Thomson & Mackinnon, 1911: 668-670, Pl. 62 fig. 4, Pl. 65 Fig. 2, Pl. 67 fig. 3.

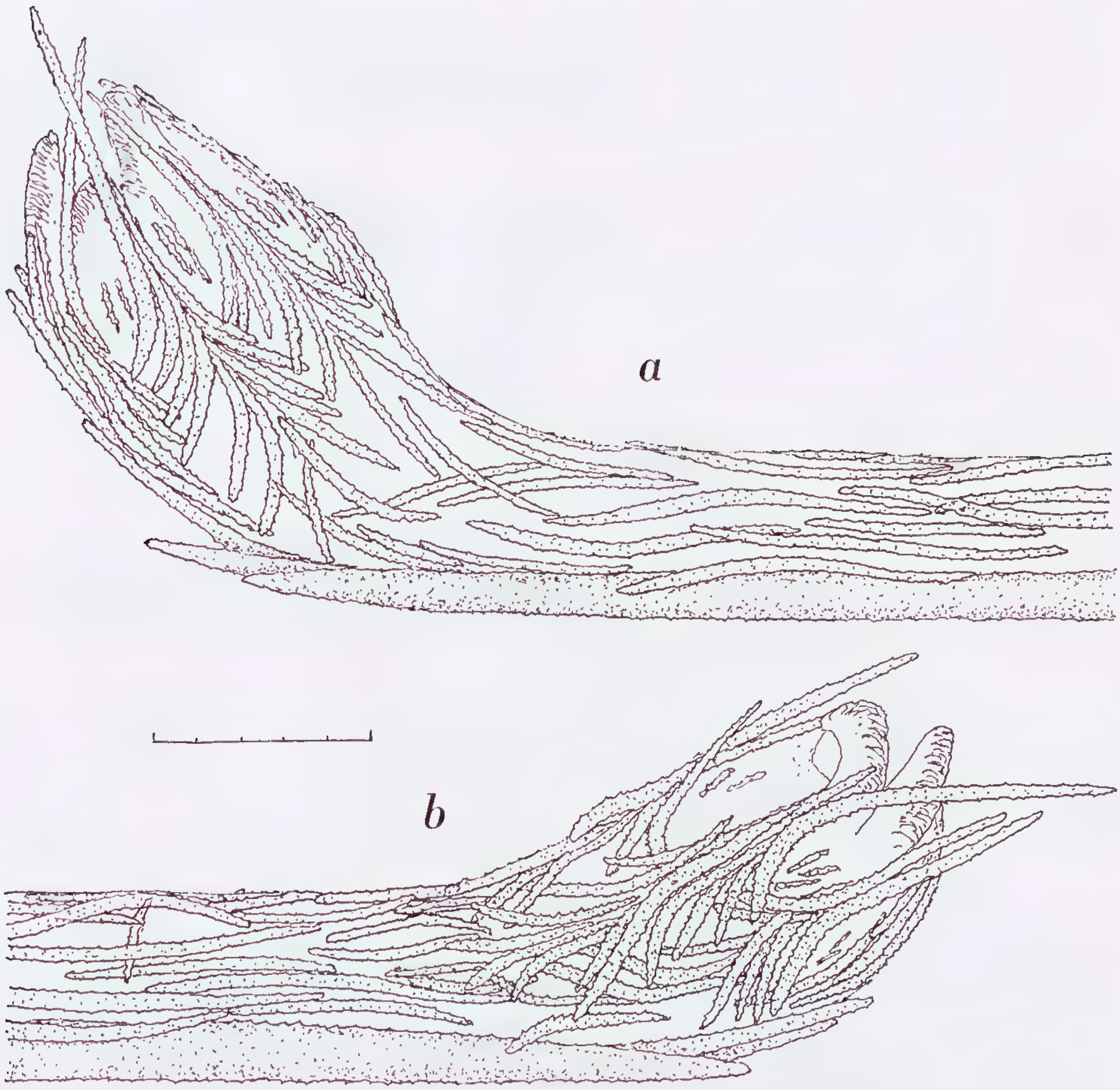

Fig. 6. *Dendronephthya (Morchellana) waitei* Thomson & Mackinnon, type specimen, AM G12191. **a-b,** polyps. (Both figures drawn to the same scale; Scale line = 0.5 mm)

MATERIAL: Thetis Expedition, Sta.25, Newcastle Bight, N.S.W., Australia, depth 77 to 88 m (42 to 48 fathoms). AM G12191, type specimen.

DESCRIPTION: Thomson & Mackinnon's picture (1911, Pl. 62 fig. 4) of the type specimen gives a very good impression of the colony. In Pl. 6 a fragment of the polyparium is reproduced.

According to the authors just mentioned (1911: 669) the polyps 'occur in bundles of about six, in typically "glomerate" arrangement'. We think, however, that the mode of growth of the colony is not at all typically glomerate: there is a profuse branching of the polyparium, and the grouping of the bundles of polyps into roundish bundles is far from clear. In our opinion the species belongs to the Umbellatae, so to the subgenus *Morchellana*. The terminal

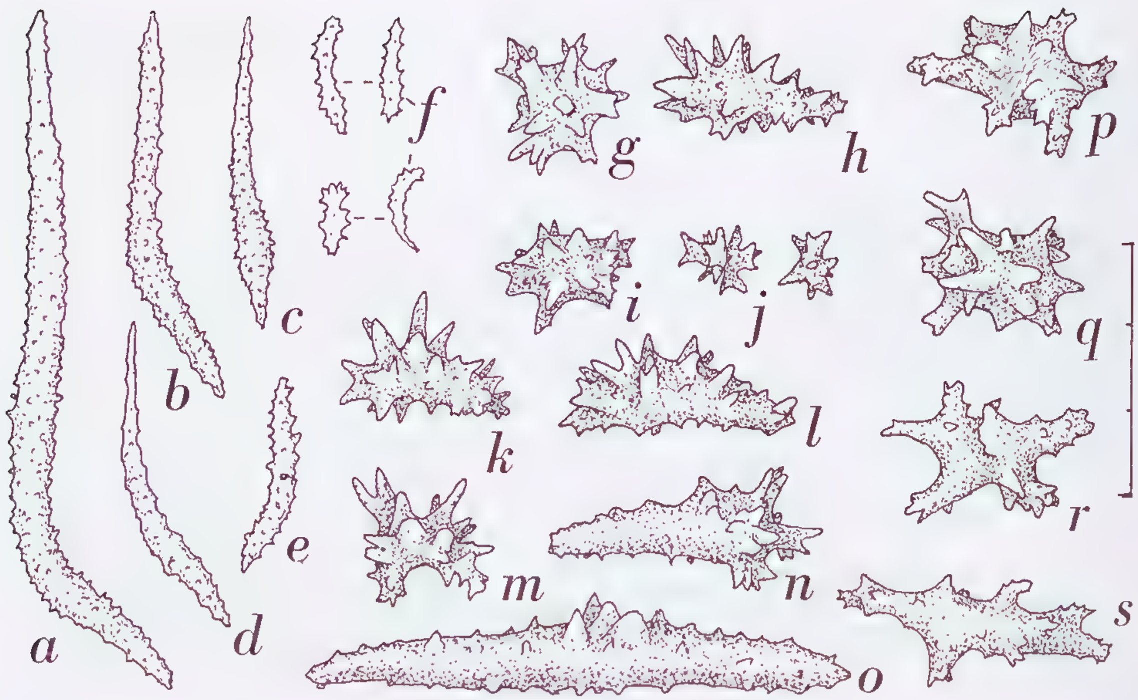

Fig. 7. *Dendronephthya (Morchellana) waitei* Thomson & Mackinnon, type specimen, AM G12191. **a-e,** anthocodial spicules; **f,** sclerites from tentacles; **g-o,** sclerites from surface layer of the base of the sterile stalk; **p-s,** sclerites from interior of the sterile stalk. (All figures drawn to the same scale; Scale line = 0.3 mm)

twigs form corymblike aggregates of polyps, with more than six polyps in one corymb. These aggregates bear a great resemblance to the corymbs, e.g., in the umbellate colony of *D. sinensis,* represented by Pütter, 1900, Pl. 30 fig. 12, and by Kükenthal, 1905, Pl. 30 fig. 40. The sparse occurrence of branches on one side of the colony also points to the Umbellatae.

In each corymb there are a few long-stalked polyps (Fig. 6). The stalks, up to 2 mm long, are straight; the width is 0.40 mm. The anthocodiae, 0.80 to 0.90 mm wide, make a very obtuse angle with the stalk, giving the polyps a clavate appearance. The younger polyps have short, often curved stalks. The anthocodial armature consists of eight double rows of spindles arranged *en chevron*. The sulcal (ventral) and lateral rows have six to eight pairs of curved, spiny spindles, usually 0.25 to 0.50 mm long; in the asulcal (dorsal) rows there may be more spindles, nine or ten in a row (Fig. 7b-e). In each row the distalmost sclerites, up to 0.90 mm long, are hockey-stick-shaped; they project for a distance of up to 0.30 mm (Figs. 6, 7a). In the interstices between the points there are about three intermediates. The tentacles, 0.35 to 0.45 mm long, are armed with transversely arranged, toothed scales, 0.10 to 0.15 mm long (Fig. 7f).

In the full-grown polyps the supporting bundle is strong. It consists of one straight spindle up to 4 mm long and 0.17 mm wide, accompanied by a few shorter ones. In the younger polyps the supporting bundles are weak. In the polyp-stalks there are thin, curved, nearly smooth spindles.

Anthocodial grade and formula: II = 1P + (5-7)p + 0 Cr. + strong S.B. + (1-2) M.

In the surface layer of the upper part of the colony thin spindles and needles occur; they bear low cones, which are wide apart. For dimensions see Thomson & Mackinnon, 1911: 669. The surface layer of the base of the sterile stalk has stars, club-shaped forms, and spindles up to 1 mm long; many of them have higher spines on one side (Fig. 7g-o). The canal-walls contain irregularly shaped, starlike sclerites, 0.18 to 0.36 mm in diameter or in length (Fig. 7p-s).

REMARKS: Thomson & Mackinnon (1911: 669) think that in certain features *D. (M.) waitei* approaches *D. maxima* Kukenthal. In our opinion there is a closer resemblance to *D. (M.) sinensis* (Pütter); see Pütter, 1900: 455-456, Pl. 29 fig. 6, Pl. 30 fig. 12, and Kükenthal, 1905: 649-650, Pl. 30 fig. 40. However *D. (M.) sinensis* has (a) four to six pairs of spindles in each anthocodial point, (b) one intermediate between two adjacent points, (c) longer tentacles, and (d) different coenenchymal sclerites.

Nephthea legiopolypa sp. nov.

Fig. 8, Pl. 7B

MATERIAL: Lizard Is., Great Barrier Reef, west tip of Palfrey Is., on reef slope, depth 4.5–6 m, rubble, sand and corals, 3 November 1975. H.K. Larson no. DFH 75-254, AM G14806, one colony, holotype.

DESCRIPTION: The rather flabby colony measures 105 mm in total height (Pl. 7B). The sterile stalk is 40 mm high and 25 to 30 mm wide; it is furrowed longitudinally. The distal part of it is covered by the undermost branches. The capitulum is flattened laterally; it is 60 mm wide and 30 to 35 mm thick.

The stem gives off some side-branches, which are thickly set with lobules. The latter are often cone-shaped, 6 to 7 mm high and 4 mm wide. Others are smaller and spherical.

The lobules are densely covered with polyps, which are practically stalkless. The anthocodiae are about 0.60 mm high and 0.65 mm wide (Fig. 8a); the tentacles are incurved. At the asulcal side of an anthocodia there are a few rods, 0.12 to 0.18 mm long; they are longitudinally arranged and are provided with high, blunt-ended processes (Fig. 8b). There are also some more or less flattened sclerites, 0.09 to 0.11 mm long (Fig. 8c, d). The greater part, however, consists of oval or finger-biscuit-like or slightly irregularly shaped small bodies, 0.03 to 0.07 mm long (Fig. 8e). The latter also occur in the tentacles. The supporting bundle is weak, ensheathing; it consists of a few spiny spindles. The largest ones are up to 1.20 mm long. One or two may project for a distance of 0.20 or 0.30 mm beyond the anthocodia.

The surface layer of a branch has a mixture of slender, spiny rods, up to 1.00 mm long (Fig. 8f) and numerous small, more or less rod-shaped sclerites, 0.07 to 0.15 mm long, provided with some low cones (Fig. 8h, i). The sclerites represented in Fig. 8g are transitional forms. In the surface layer of the middle part of the sterile stalk there are shorter rods, up to about 0.40 mm long (Fig. 8j, m) and a great many irregularly shaped bodies: some are dumb-bells, 0.08 to 0.12 mm in diameter (Fig. 8k), others are short 'caterpillars', up to 0.16 mm long (Fig. 8l). In the basal part of the stalk some sclerites are larger and fantastically shaped, and up to 0.45 mm long (Fig. 8n, o, q), but there are also numerous small sclerites, 0.10 to 0.20 mm in length or in diameter: crosses, dumb-bells, etc. (Fig. 8p).

The coenenchyme of the sterile stalk has: (1) large, branched or unbranched spindles, up to 2.20 mm long, covered with small, blunt spines or with higher, larger spines (Fig. 8r), and (2) numerous small sclerites: three- or four-radiated forms, irregular spindles, etc.; diameter 0.25 to 0.50 mm (Fig. 8s –v).

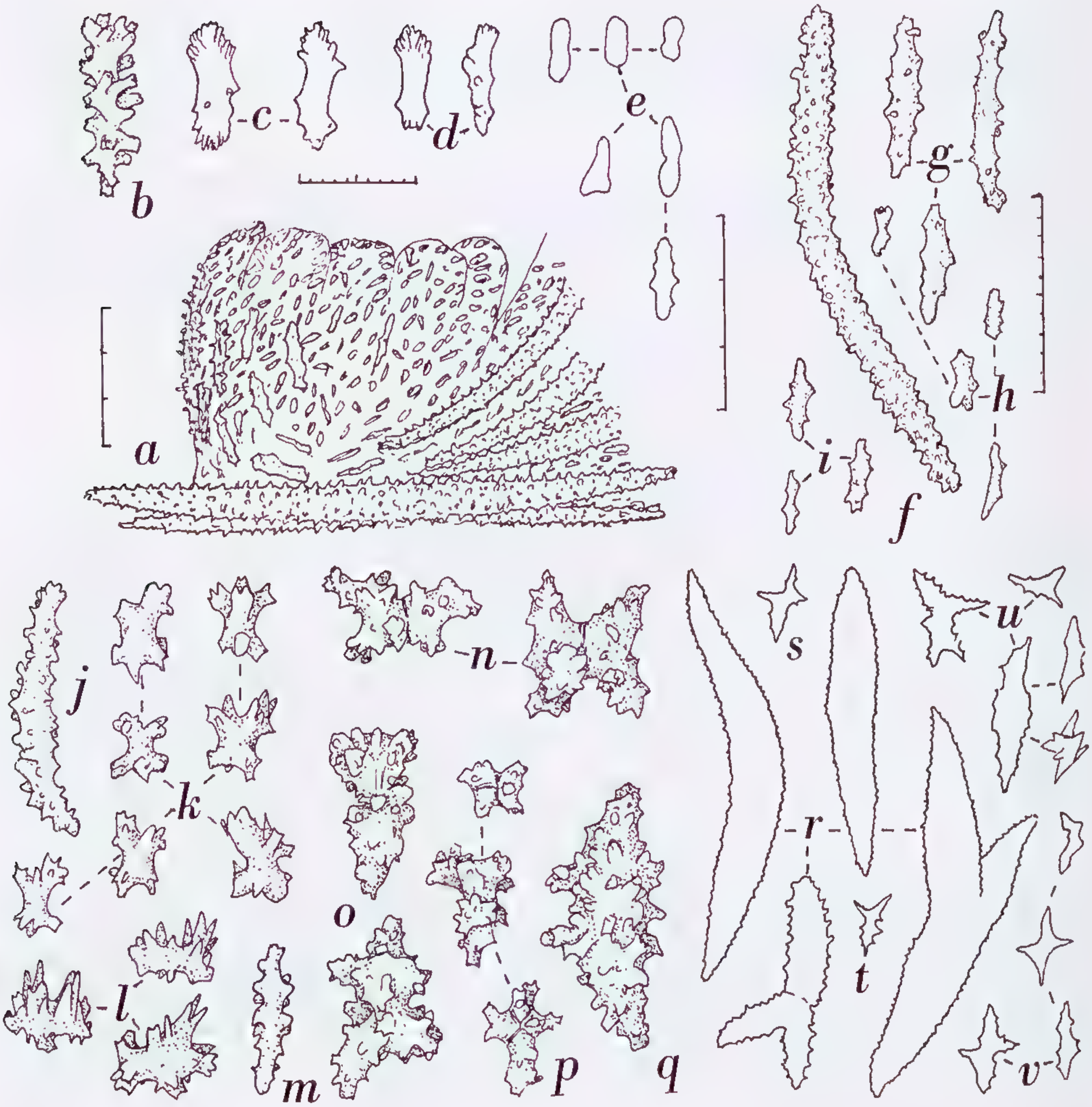

Fig. 8. *Nephthea legiopolypa* sp. nov., holotype, AM G14806. **a,** polyp; **b-e,** anthocodial sclerites; **f-i,** sclerites from surface layer of a branch; **j-m,** sclerites from surface layer of the middle of the sterile stalk; **n-q,** sclerites from surface layer of the base of the sterile stalk; **r-v,** sclerites from coenenchyme of the sterile stalk. (Enlargement of **a** indicated by 0.3 mm scale to the left of **a**; that of **b-e** by 0.1 mm scale below **c-d**; that of **f-q** by 0.3 mm scale between **e** and **i**; that of **r-v** by 1 mm scale to the right of **g-h**.)

Colour. In alcohol the colour is creamy-light brown.

REMARKS: The species is characterized by the crowded, stalkless polyps with a remarkable armature. The specific name refers to these tight-packed polyps (Latin *legio* = large number).

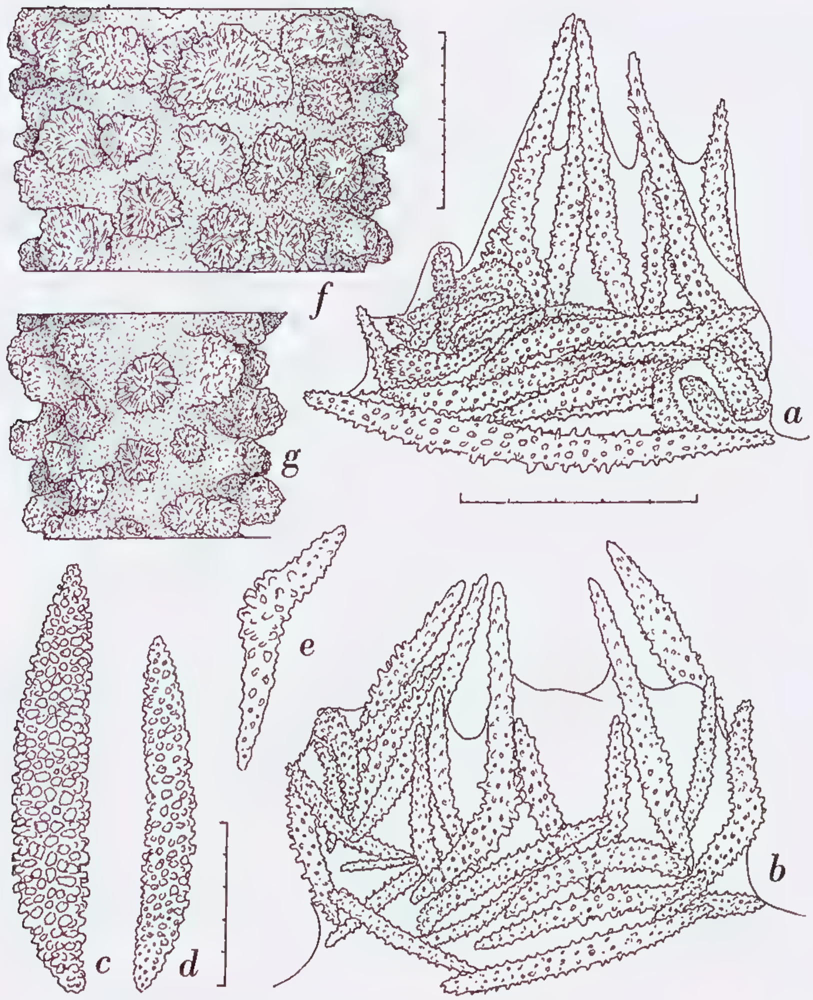

Fig. 9. *Scleronephthya pallida* (Whitelegge), type specimen, AM G1543. **a, b,** polyps; **c-e,** spicules from coenenchyme of the base; **f-g,** prominences on coenenchymal sclerites. (Enlargement of **a, b** indicated by 0.5 mm scale below **a**; that of **c-e** by 0.5 mm scale at **d**; that of **f, g** by 0.1 mm scale to the right of **f**.)

Scleronephthya pallida (Whitelegge, 1897) n. comb.
Fig. 9, Pl. 7A

Spongodes pallida Whitelegge, 1897: 221-222, Pl. 12 fig. 7a-c.
non *Stereonephthya whiteleggi* Kükenthal, 1905: 705-707, Pl. 32 fig. 57; Utinomi, 1971: 95-96, Pl. 15 fig. 6.
non *Stereonephthya whiteleggei* Kükenthal, 1910, 57-58, Pl. 3 fig. 23.

MATERIAL: Funafuti Atoll, Ellice Is. AM G1543, one colony, Whitelegge's type specimen.

In 1905 Kükenthal identified a specimen from the Hamburg Museum with Whitelegge's *Spongodes pallida* and described it under *Stereonephthya whiteleggi* nom. nov. In 1910 he adopted the spelling *S. whiteleggei*. A comparison of both the short re-description below and Whitelegge's description (1897) with those of Kükenthal (1905, 1910) and Utinomi (1971) clearly shows that the colonies described by the latter authors are quite unlike *'Spongodes*

pallida'. Kükenthal's figures (1905, Fig. L²; 1910, Fig. 29) and Utinomi's picture (1971, Text-fig. 6) of polyps remove all doubt on this point.

A single glance at Whitelegge's Pl. 12 fig. 7b (1897) already suffices to show that the polyps lack supporting bundles. One might be inclined to ascribe this absence to the drawer of the figure, but re-examination showed that the drawing is correct: a supporting bundle is in fact wanting. The polyps are radially symmetrical, a sulcal and an asulcal side cannot be distinguished as easily as in *Dendronephthya* and *Stereonephthya*. The drawings Fig. 9a and b have been made from an old slide, present in the Australian Museum, and mounted by Whitelegge himself. These drawings show that the anthocodial armature consists of crown and points. The crown is composed of about four rows of spindles, 0.25 to 0.60 mm long. Each point consists of one pair of nearly straight, but often slightly hockey-stick-shaped sclerites. One of each pair is longer than the other, up to 0.75 mm, and projects above the anthocodia for a distance of 0.25 to 0.30 mm. The shorter point spicule is 0.18 to 0.35 mm long. Sometimes there are two shorter sclerites. All anthocodial sclerites bear blunt spines.

The polyps are 0.80 to 1.00 mm wide, the stalk is very short or absent. The tentacles, which are withdrawn into the anthocodiae, are armoured with a number of flat, more or less rodlike, sometimes slightly clavate sclerites, 0.12 to 0.15 mm long, with toothed edges, and densely arranged *en chevron*.

In the surface layer of the stems and of the encrusting base, and also in the coenenchyme of the base, lie spindles up to 1.40 mm long, and varying in width from about 0.13 to 0.24 mm (Fig. 9c-e). They are thickly covered with blunt spines. Their summits, 0.02 to 0.04 mm in diameter (measured in a direction parallel to the longitudinal axis of the sclerite), are curiously grooved (Fig. 9f, g).

REMARKS: Striking characters of the type specimen are the absence of a supporting bundle, and the radial symmetry of the polyps and their armature. We therefore refer it to the genus *Scleronephthya* for the same reason as *S. corymbosa* Verseveldt & Cohen, 1971.

Siphonogorgia macrospina Whitelegge, 1897
Pl. 8

Siphonogorgia macrospina Whitelegge, 1897: 224-225, Pl. 12 fig. 8a-d; Thomson & Simpson, 1909: 131-132, Pl. 9 fig. 8; Thomson & Dean, 1931: 159-160, 171.

MATERIAL: Funafuti Atoll, Ellice Is., outside the reef, depth 73–128 m (40–70 fathoms), AM G1548; a number of fragments forming Whitelegge's type.

NOTES: A slide with a few branches mounted by Whitelegge and kept in the Australian Museum has kindly been placed at our disposal. The following observations could be made.

The anthocodiae, about 0.40 mm wide, are retracted within calyces formed by one or two stout spicules, bent sideways, and a few shorter ones, while, moreover, the anthocodiae are protected by a palisade of warty clubs standing erect and parallel to each other, the thickened ends directed upwards. The length of these clubs varies from about 0.40 to 0.80 mm. The clavate spicule represented in Thomson & Simpson's Pl. 9 fig. 8 (1909), in the middle to the right, resembles such a club.

The anthocodial armature consists of crown and points. The crown, probably up to eight rows deep, is composed of smooth, curved spindles, 0.33 mm (or more ?) mm long. Each of the points consists of five to eight bent, smooth spindles, arranged *en chevron*; they are 0.20 to 0.30 mm long.

The spicules in the outer layer of the fragments are up to 6 mm long and 0.45 mm wide. Some of them are very sinuous. All of the warts are roughly circular in outline, mostly 0.028 to 0.085 mm in diameter, and 0.035 mm high, domed or pedicellate with rugged, hillocked summits. In the canal-walls lie straight or slightly curved needles: the smaller ones, 0.15 to 0.25 mm long, have some tiny spines; the larger ones, up to 1.60 mm long (Whitelegge: 1.80 mm; see his Pl. 12 fig. 18c) and 0.05 mm wide, are smooth.

ACKNOWLEDGEMENTS

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Plate 1. *Alcyonium etheridgei* Thomson & Mackinnon. **A**, holotype, AM G12170. **B**, paratype, AM G12173. **C**, paratype, AM G12172.

Plate 2. *Lobophytum crassum* Von Marenzeller, type specimen of *L. hedleyi* Whitelegge, AM G1537. **A**, colony seen from above; **B**, side-view.

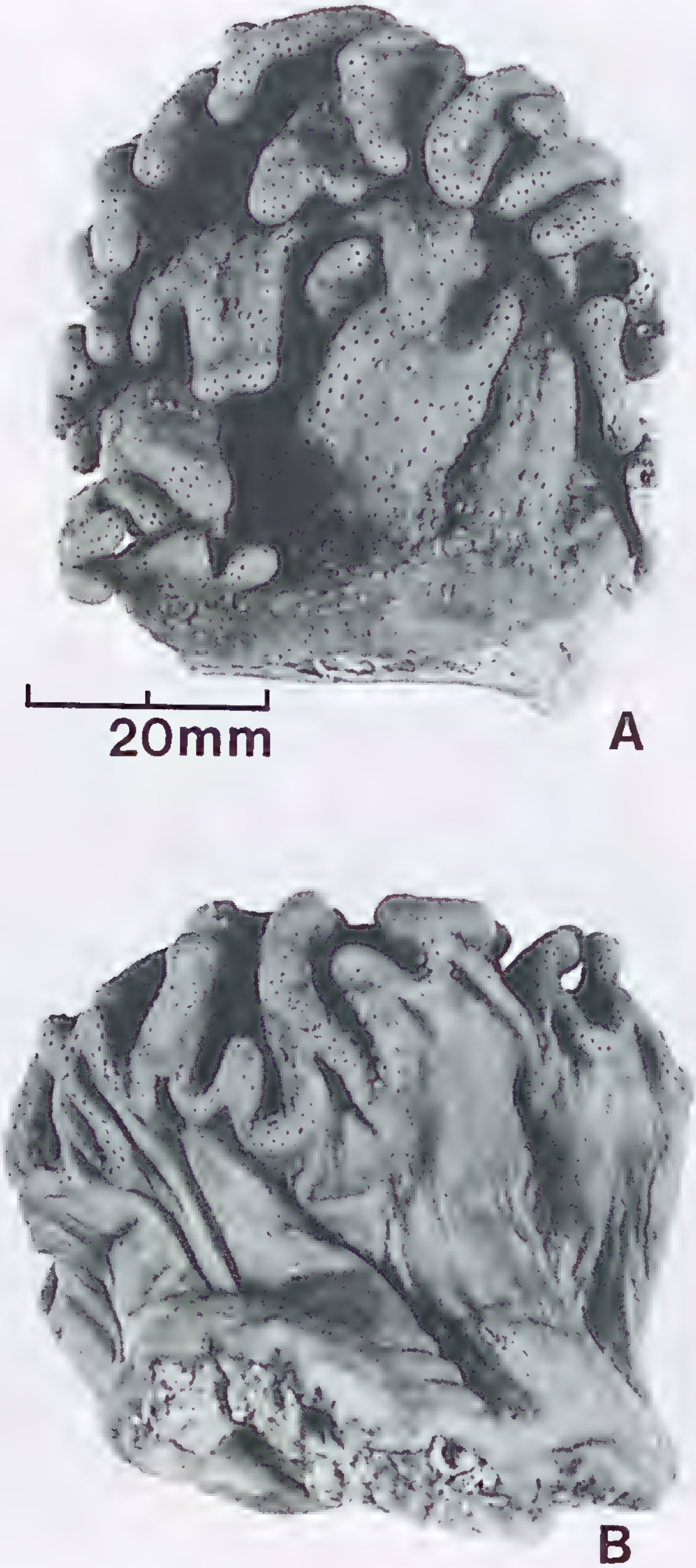

Plate 3. *Lobophytum crassum* Von Marenzeller, paratype of *L. hedleyi* Whitelegge, AM G1537. **A**, colony seen from above; **B**, side-view.

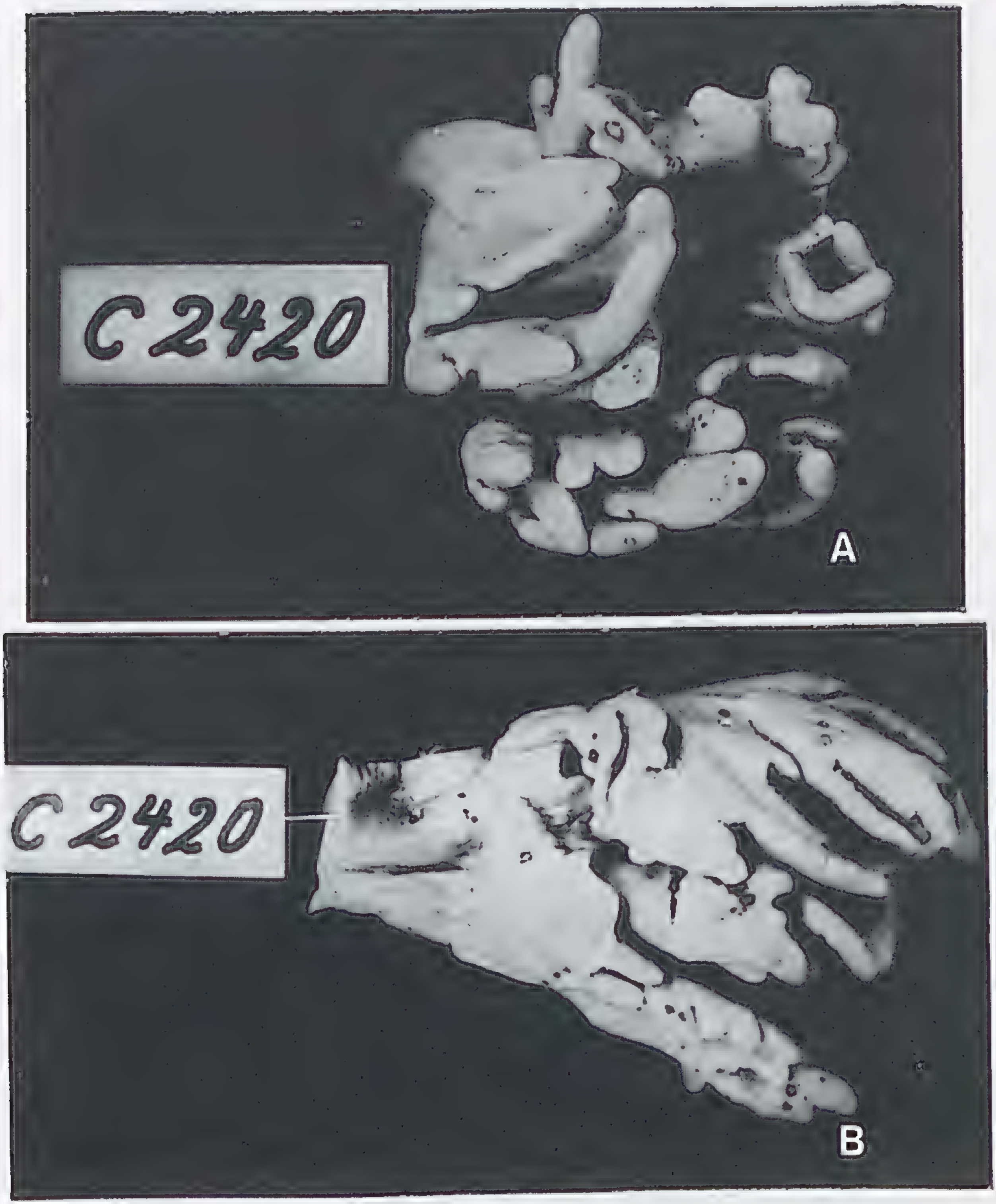

Plate 4. *Lobophytum crassum* Von Marenzeller, type specimen, photograph Museum Godeffroy, Hamburg. **A**, colony seen from above; **B**, side-view.

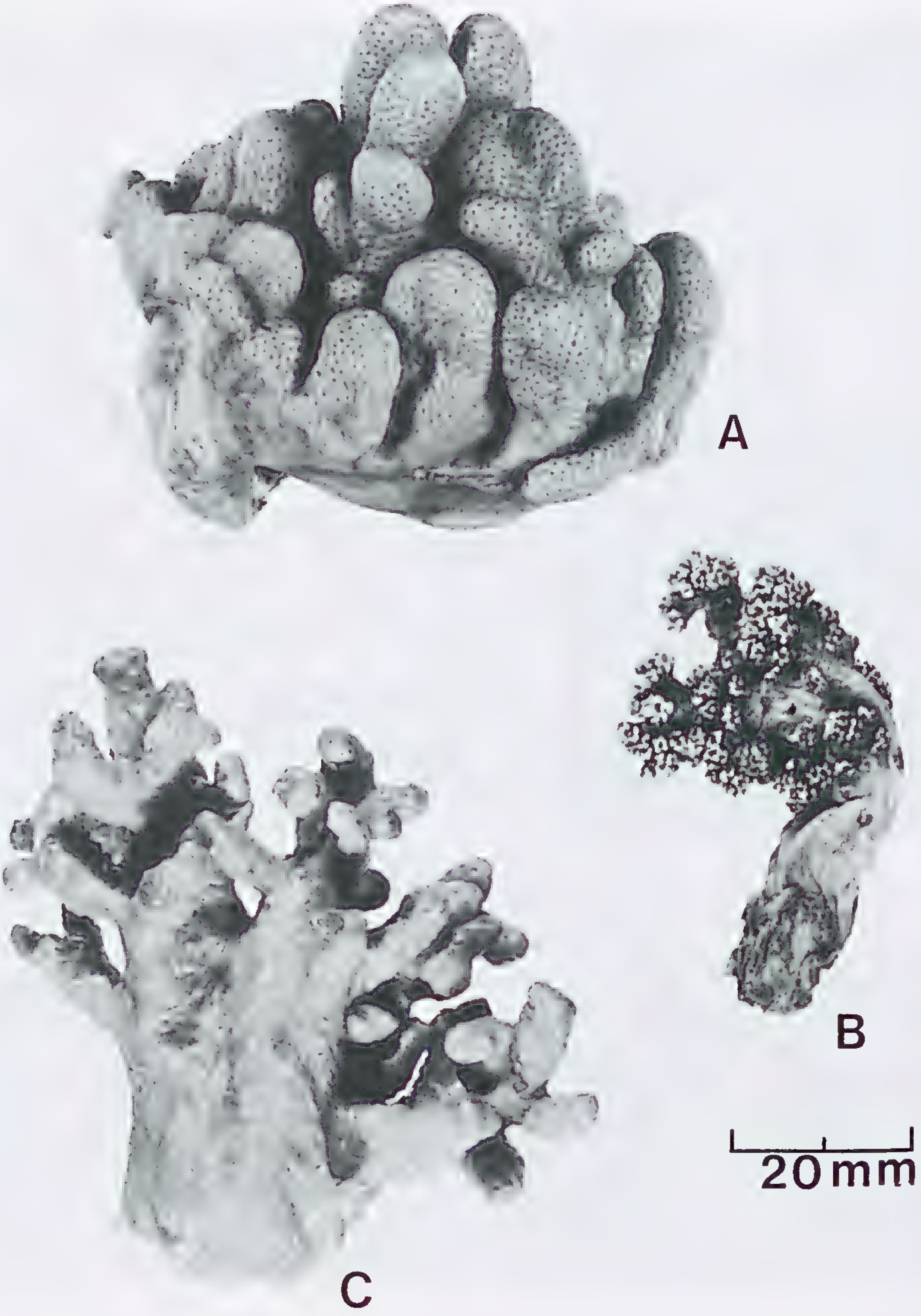

Plate 5. **A,** *Sinularia densa* (Whitelegge), type specimen, AM G1541. **B,** *Dendronephthya (Morchellana) australis* Kükenthal, RMNH Coel. no. 12299. **C,** *Sinularia larsonae* sp. nov., holotype, AM G14800. (All to same scale.)

Plate 6. *Dendronephthya (Morchellana) waitei* Thomson & Mackinnon, type specimen, AM G12191; fragment of the polyparium.

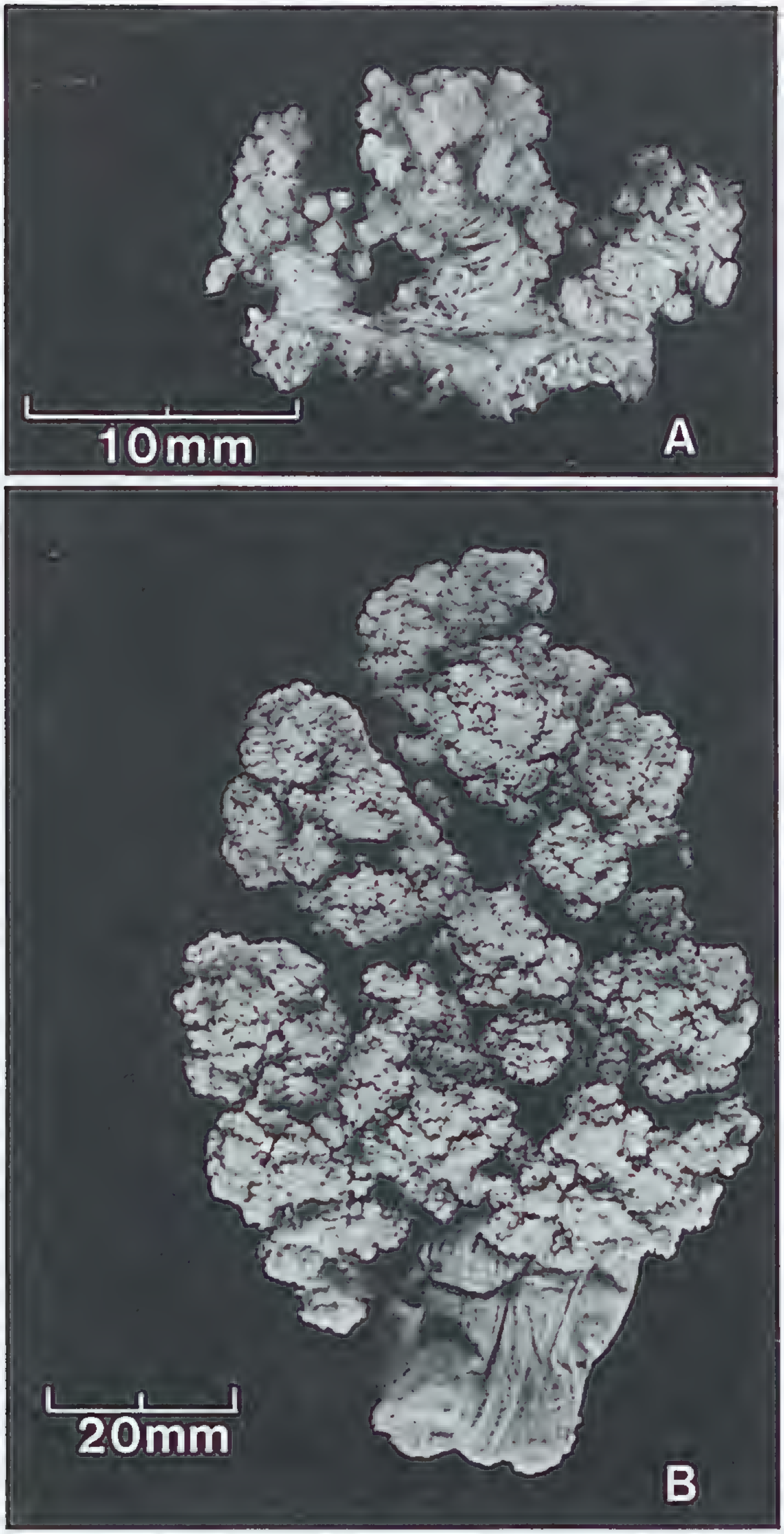

Plate 7. **A,** *Scleronephthya pallida* (Whitelegge), type specimen, AM G1543. **B,** *Nephthea legiopolypa* sp. nov., holotype, AM G14806.

Plate 8. *Siphonogorgia macrospina* Whitelegge, fragments of type specimen. AM G1548.